New Scientist

WEEKLY 10 February 2024

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The dark side of the universe

Hear cosmologist Katherine Freese recount stories from her book *The Cosmic Cocktail: Three parts dark matter*, from historic discoveries to the deluge of data from underground labs, space satellites and particle accelerators. Learn whether we are close to solving the mystery of what glues galaxies together in this online talk at 7pm EST on 21 February/ 12am GMT on 22 February.

newscientist.com/events

Tour

Dark and frozen matter: Switzerland and France

Have your mind blown at Europe's particle physics centre CERN, which houses the world renowned Large Hadron Collider. The tour includes a lecture series by particle physicist Darren Price and a tour of Geneva's old town. You will also head to Chamonix to explore Mont Blanc. This six-day tour starts on 5 May and costs £3098.

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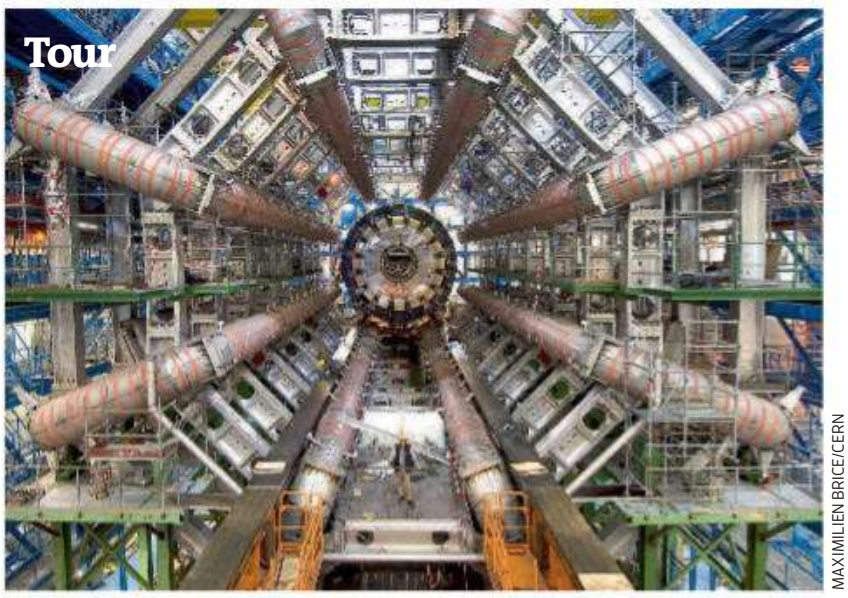


MAXIMILIEN BRICE/CERN

ATLAS experiment Visit the world's premier particle physics lab

NASA

Extreme beans Growing plants in the harsh environment of space

Podcast

Weekly

The team unpack Neuralink's ambitions for human brain implants. There is a new study that reveals the secret physiology of a long life – if you are a dog, that is. Hear why tiny tornadoes inside some animal cells are key to life. Plus, the team discuss the discovery of an ancient gadget that helped turn fibres into rope 37,000 years ago.

newscientist.com/nspod

Video

Antique clock marvels

Intricate clocks called *zimingzhong* in Mandarin, or "bells that ring themselves", were brought to China by European missionaries during the Qing dynasty and were highly prized by Chinese emperors. These lavish machines don't just represent time, but serve as windows into a period of cutting-edge scientific innovation and collaboration.

youtube.com/newscientist

Newsletter

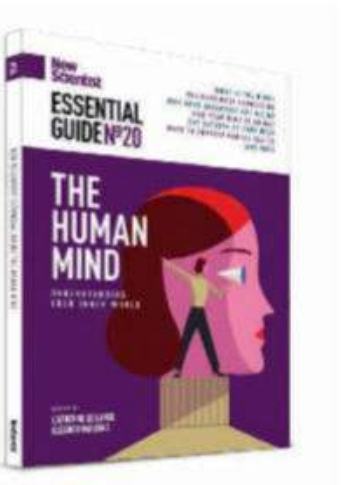
Launchpad

Space reporter Leah Crane explores the many reasons for growing plants in space. Aside from testing out how to grow food for future extraterrestrial civilisations, being around plants can have remarkable psychological benefits for astronauts stuck on board space stations for long periods of time.

newscientist.com/launchpad

Podcast

"Surprisingly, purebred dogs seemed to live longer than those in the category of crossbreeds"



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Eyes on the prize

We need to focus on reaching net-zero emissions, not on arbitrary temperature limits

IT'S not often that global news is garnered from a sponge. But that is what we find ourselves debating this week.

Researchers studying long-lived sea sponges to track the average global surface temperature over 300 years have made a startling discovery: when delegates at the Paris climate conference in 2015 agreed to aim to limit warming to 1.5°C above pre-industrial levels, it may have already been too late. According to data from the sponges, the world was already more than 1.5°C hotter as a result of the burning of fossil fuels (see page 9).

This conclusion is controversial. A key issue is that this species of sponge lives only in the Caribbean. Even if its skeleton does accurately record past temperature changes, extrapolating globally from one region is questionable. However, the idea that fossil fuels have warmed the planet somewhat more than the official figures suggest is plausible.

But debates about whether we have passed 1.5°C distract from the bigger picture. What really matters is that the current level of global warming is already dangerously high, and that further warming will be even more disastrous.

"Debates about whether we have passed 1.5°C distract from the bigger picture"

We are already seeing ever more extreme weather events around the world, with record-breaking heatwaves, floods and droughts. These extremes are causing increasingly serious knock-on effects.

They are reducing productivity, damaging crops, driving up food prices and creating political instability. They are destroying homes and reversing hard-won social and economic advances. They are also disrupting trade, with low water levels in Europe and the Panama Canal affecting shipping (see page 14).

To prevent things from getting much worse, we need to stop the world warming further. Achieving this will require global greenhouse gas emissions to reach net zero. All the focus should therefore be on reducing emissions, not on discussing rather arbitrary temperature limits.

And with global emissions still rising, we have an awful lot of work to do. ▮

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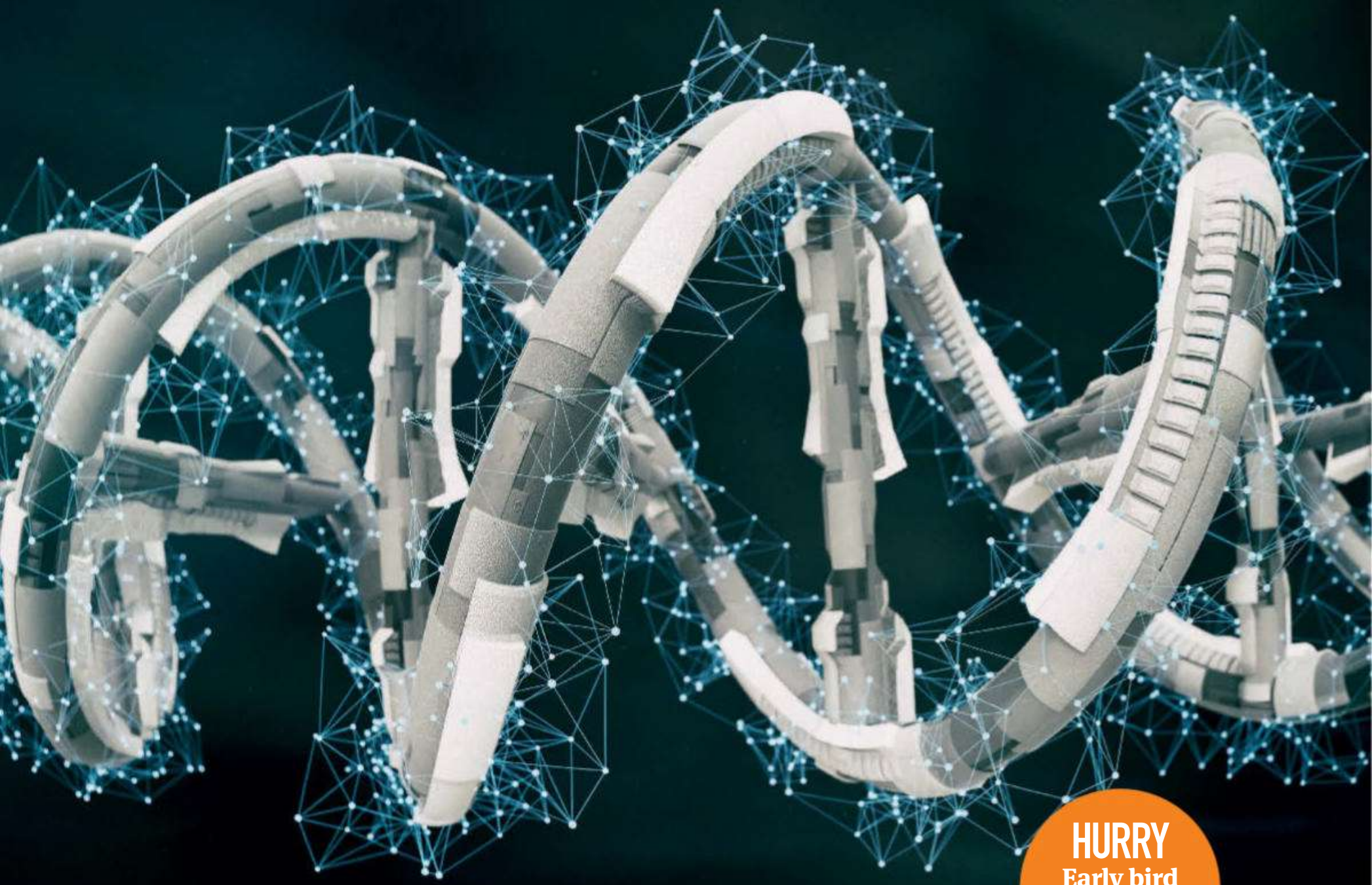

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Goodbye Ingenuity
Mars helicopter ends its mission but leaves a strong legacy **p17**

Flight height
Adjusting plane altitudes could slash climate impact **p18**

Renewable energy

The blades of future giants

These are the world's largest onshore wind turbine blades, each 131 metres long. They are made by Chinese firm SANY Renewable Energy. Once they are installed in central China, the 15-megawatt, three-bladed turbines will each sweep an area of nearly 54,000 square metres, or about seven times the size of a football pitch.

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Space

Bennu may be from an ocean world

A sample from the asteroid, brought back by NASA's OSIRIS-REx mission, hints it was once part of a small planet with conditions favourable for life to emerge, finds **Joshua Howgego**

AN ASTEROID sample brought back to Earth may once have been part of a small, ocean-covered world with conditions favourable for life to emerge. That's according to the team behind NASA's OSIRIS-REx mission, which returned a sample of the asteroid Bennu in September 2023.

"My working hypothesis is that this was an ancient ocean world," says Dante Lauretta at the University of Arizona, the mission's principal investigator. The sample also contains structures that could give clues about the origins of life, he adds.

After its launch in 2016, OSIRIS-REx travelled to Bennu, a dark-coloured and carbon-rich asteroid about the size of the Empire State Building that has an orbit similar to Earth's. It aimed to bring back 60 grams of material, but its haul weighs roughly twice that. That makes it the largest sample of an asteroid ever returned to Earth. The Japanese mission Hayabusa returned a few tiny grains from the asteroid Itokawa in 2010 and its successor, Hayabusa2, returned almost 6 grams from the asteroid Ryugu in 2020.

NASA/GODDARD/UNIVERSITY OF ARIZONA

Researchers processing samples from asteroid Bennu (pictured inset)

Exposed to water

Lauretta is basing his hypothesis on the analysis of the material carried out over the past few months, which hasn't yet been published. This includes X-ray diffraction, a technique that reveals the minerals in the sample. Most of the rock is made of clays, including minerals called serpentinites. On Earth, such substances form when rock from Earth's mantle is pushed upwards into the seabed and exposed to water. The reaction is exothermic, meaning it generates heat.

The team has also found that some of Bennu's dark rock is coated with a thin crust of brighter material. Lauretta says this is a calcium and magnesium-rich phosphate mineral that is very rare. "I had never seen it before," he says. However, the same material has been detected in the plumes of water that shoot out from the surface of Saturn's moon Enceladus. This world is assumed to have an ocean of liquid water beneath its icy crust and its seabed is considered to be one of the most plausible locations in the solar system for life to conceivably start.

If you put that all together, says Lauretta, it suggests that Bennu was once part of an ocean world in the early solar system, akin to Enceladus but probably only about half as big. That original world, known as a planetesimal, would have been destroyed in a collision, with the resulting rubble later coalescing into thousands of asteroids, one of which is Bennu.

"There are indeed similarities between the mineralogy of Bennu and what has been found on Enceladus," says Fabian Klenner at the University of Washington in Seattle. Lauretta's hypothesis is "incredibly exciting", he says.

Sara Russell at London's Natural History Museum is part of the team that has been analysing the Bennu sample. She says the asteroid is full of minerals that would have formed through the action of hot water. However, she says Bennu itself would have held its water in its internal pores. "I don't imagine blue waves of oceans covering the asteroid. I think the liquid would evaporate at the surface, unfortunately," she says.

"These could be exciting from an origin-of-life perspective. They're like protocells"

Lauretta has also found what he calls "nanoglobules" in the rock sample. These are tiny, bubble-like structures that can be thought of as like droplets of oil in water. "These could be exciting from an origin-of-life perspective. They're like protocells," he says.

These are evidence of compartmentalisation, says Lauretta. Living things today are highly compartmentalised, for example into cells. Because of this, the separation of groups of chemicals is thought to be a key step in the emergence of life. "If you can get that, that's where metabolism could maybe start to originate," says Lauretta.

He stresses that he isn't claiming any evidence for life, but "origins of life is a big area of study for these samples", he says.

Studying hydrothermal vents on Earth's seabeds is one way to work out how chemistry can transition into biology, but the picture here is complicated by there being all kinds of life present now. The sample from Bennu offers a preserved snapshot of the kinds of environment that we think can produce life, but without any contamination from life that emerged later. ▮

Genetics

Blue eyes may be better in dim light than brown eyes

Michael Le Page

PEOPLE with blue eyes can read better in darker conditions than those with brown eyes, a small study has found. This suggests having blue eyes is an advantage in low-light conditions, and might help explain why the trait evolved in northern Europe.

Kyoko Yamaguchi at Liverpool John Moores University, UK, and her student Faith Erin Cain tested the vision of 40 people of European descent who have either blue or brown eyes. After the volunteers sat in darkness for 30 seconds, the pair increased the lighting until people could read a sequence of letters on a wall 3 metres away. Those with blue eyes needed a light level of 0.7 lux on average, compared with 0.82 lux for those with brown eyes (bioRxiv, doi.org/mfxt).

Blue eyes helping in dim conditions makes sense, says Cassie Ludwig at Stanford University in California, but the number of volunteers in this study was too small to draw firm conclusions.

If the finding is confirmed, it might help explain why blue eyes evolved in some populations in northern Europe, says Yamaguchi.

The current thinking is that blue eyes were a side effect of selection for lighter skin and blonde hair, and the driving force behind this was a need to get sufficient vitamin D. Our bodies use ultraviolet rays to make vitamin D in the skin, so darker skin can result in vitamin D deficiency in regions with little sunlight.

It may also be that blue-eyed people were seen as attractive, says David Mackey at the Lions Eye Institute in Australia. But "seeing better at night in the northern winter would have some advantages", he says.

However, blue eyes may be a disadvantage in bright light. Some studies suggest that blue irises scatter more light than brown ones, degrading image quality. ▮

Environment

Temperatures may have passed 1.5°C of warming a decade ago

Michael Le Page

THE world is already 1.8°C warmer than it was in pre-industrial times, having passed the 1.5°C limit in 2010 or 2011, claim researchers who used sea sponges to work out how temperatures have changed in the Caribbean over the past 300 years.

"The increase in global mean surface temperature has been half a degree greater than the current accepted estimates," says Malcolm McCulloch at the University of Western Australia. "What our work says is that we are a decade more, or further, advanced in the global warming scenario."

However, data from a single region isn't a reliable way to work out global temperatures, says another climate scientist.

The 2015 Paris Agreement called on countries to limit warming to 1.5°C above pre-industrial levels, but didn't define what this meant. Climate scientists writing reports for the Intergovernmental Panel on Climate Change (IPCC) have defined it based on the average temperature between 1850 and 1900.

By this time, the planet had already begun warming as a result of emissions from the burning of fossil fuels. But because there were few temperature measurements before 1850, there is uncertainty over how much fossil fuel-driven warming there was early on during the industrial age.

"The temperature increase has been half a degree greater than the accepted estimates"

McCulloch and his colleagues think they have found out by analysing *Ceratoporella nicholsoni* sponges that form a calcium carbonate skeleton.

A 10-centimetre-wide sponge could be about 400 years old, says team member Amos Winter at Indiana State University. "These sponges are extremely slow-growing."

The sponges were collected off the coast of Puerto Rico by divers at depths of between 33 and 91 metres. The team measured the ratio of strontium to calcium, which varies according to the water temperature when the calcium carbonate formed. This helped reveal a close correlation between the temperatures as "recorded" by the sponges and the average global surface temperature measured by instruments, especially after 1960 when measurements became more reliable.

"The connection is very robust," says McCulloch.

The team then used this to calculate the pre-industrial global average temperature going back to 1700 (*Nature Climate Change*, doi.org/mfzq).

The researchers think the IPCC should take their work into account when it comes to assessing whether the 1.5°C limit has been passed. McCulloch also thinks climate modellers need to factor in the findings. If carbon dioxide emissions so far have caused more warming than thought, the impact of further emissions may be being underestimated, he says.

Michael Mann at the University of Pennsylvania is unconvinced. "It begs credulity to claim that the instrumental record is wrong based on palaeo-sponges from one region of the world," he says. "That having been said, our own earlier work does support the notion that there was at least an additional 0.2°C of warming before the late 19th century."

Human-caused warming may have begun thousands of years earlier. According to the early Anthropocene hypothesis, deforestation by the first farmers and the creation of rice paddies generated enough CO_2 and methane to stop the planet cooling and entering a new glaciation. ▮

Activists at the COP28 climate conference in Dubai in December 2023

SEAN GALLUP/GETTY IMAGES

Technology

Fusion reaction milestone confirmed

The US National Ignition Facility has achieved even higher energy yields since breaking even for the first time in 2022, but a practical fusion reactor is still a long way off, says **Matthew Sparkes**

SCIENTISTS have confirmed that a fusion reaction in 2022 reached a historic milestone by unleashing more energy than was put into it – and subsequent trials have produced even better results. The findings, now published in a series of papers, give encouragement that fusion reactors will one day create clean, plentiful energy.

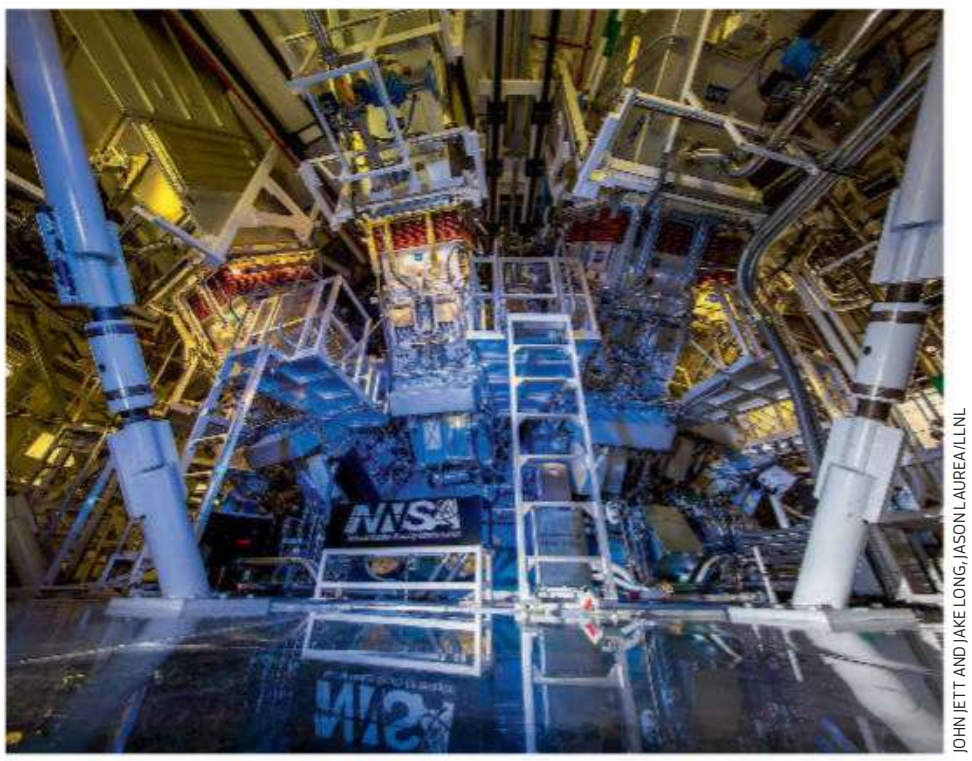
"There is a chance that we will have fusion. But the challenges that we have are pretty steep"

Today's nuclear power plants rely on fission reactions, where atoms are smashed apart to release energy and smaller particles. Fusion works in reverse, squeezing smaller particles together into larger atoms; the same process powers our sun.

Fusion can create more energy with none of the radioactive waste involved in fission, but finding a way to contain and control this process, let alone extract energy from it, has eluded scientists and engineers for decades.

Experiments to do this using capsules of deuterium and tritium fuel bombarded with lasers – a process called inertial confinement fusion (ICF) – began at the Lawrence Livermore National Laboratory (LLNL) in California in 2011. The energy released was initially only a tiny fraction of the laser energy put in, but it gradually increased until an experiment on 5 December 2022 finally passed the crucial milestone of breaking even. That reaction put out 1.5 times the laser energy required to kick-start it.

The lab's National Ignition Facility (NIF) says trial runs since have yielded greater ratios, hitting 1.9 times the energy input on 4 September 2023 (*Physical Review Letters*, doi.org/mfzr).



JOHN JETT AND JAKE LONG, JASON LAUREA/LLNL

Fusion happens inside the Target Chamber at the US National Ignition Facility

Richard Town at the LLNL says the team's checks since the 2022 result have proved that it "wasn't a flash in the pan".

Even with the hardware at NIF, Town says it is likely that yields could be improved, but if the lasers can be upgraded, things could be pushed even further. "A bigger hammer always helps," he says. "If we can get a bigger hammer, I think we could get to target gains of about roughly 10."

To create fusion ignition, laser energy is converted into X-rays in a hohlraum

But Town points out that NIF wasn't built to be a prototype reactor and isn't optimised for boosting yields. Its main job is to provide research for the US nuclear weapons programme.

Part of this involves exposing electronics and payloads from nuclear bombs to the neutron bombardment that takes place when ICF reactions occur, to check that they will function in the event of nuclear war. The danger of an electronics failure was highlighted during a test in 2021 when NIF fired and wiped out all lights across the site, plunging researchers into darkness.

This mission means some research from the project remains classified; even the concept of ICF was a classified secret into the 1990s, says Town.

The progress at ICF will bolster hopes that fusion power is drawing closer, but there are caveats.

The energy output still falls far short of what would be needed for a commercial reactor, barely creating enough to heat a bath. Worse than that, the ratio is calculated using the lasers' output, but to create that 2.1 megajoules of energy, the lasers draw 500 trillion watts, which is more power than the output of the entire US national grid. So these experiments break even in a very narrow sense of the term.

Martin Freer at the University of Birmingham, UK, says these results certainly aren't an indication that practical fusion reactors can now be built. "There's still science to be done," he says. "It's not like we know the answers to all of this and we don't need researchers any more."

Freer says the engineering challenges now are to create better materials and processes. "There is a chance that we will have fusion," he says. "But the challenges that we have are pretty steep, scientifically."

Not a climate solution

Aneeqa Khan at the University of Manchester, UK, says that the progress in fusion research is positive, but it will be decades before commercial power plants are operational. She warns against thinking fusion can be a possible solution to tackle our reliance on fossil fuels.

"Fusion is already too late to deal with the climate crisis. We are already facing the devastation from climate change on a global scale," says Khan. "In the short term, we need to use existing low-carbon technologies such as fission and renewables, while investing in fusion for the long term, to be part of a diverse, low-carbon energy mix. We need to be throwing everything we have at the climate crisis." ▮

Mind

Menstrual cycle hormone changes don't actually affect cognitive skills

Grace Wade

VERBAL and spatial skills, like word memorisation and navigation, remain consistent throughout the menstrual cycle, suggesting menstruation has little effect on such cognitive functions.

Research has indicated that the menstrual cycle may affect cognition due to hormonal fluctuations. For instance, studies have shown that brain regions critical for spatial processing and memory change in size as the concentration of certain hormones ebbs and flows.

To investigate further, Belinda Pletzer at the University of Salzburg in Austria and her colleagues analysed verbal and spatial skills across the menstrual cycle in dozens of women. Participants were between 18 and 35 years old, had a consistent menstrual cycle of between 21 and 35 days in length and didn't have any underlying health conditions or use hormonal birth control.

In one study, the researchers asked 153 participants to complete three cognitive tasks. The first involved listing as many words as possible in categories with specific starting letters – for instance, listing animals beginning with the letter C. Then, they were asked to navigate a virtual environment to locate a target. Finally, they had to assess whether a pair of images showed the same 3D object in two orientations, or whether they showed two distinct objects.

Cognitive processes like memory and concentration underpin navigation

TONY ANDERSON/DIGITAL VISION/GETTY IMAGES

The participants completed these assessments once, either during their period, two to three days before ovulation or a week before their next period. These times were chosen to reflect the changing levels of the hormones oestradiol and progesterone, which the researchers monitored through saliva samples.

The same tasks were used to assess cognitive function in a separate group of 65 volunteers. In this study, however, every participant performed the tasks three times – during their period, two to three days before ovulation and a week before their next period.

In both studies, the researchers found no difference in cognitive performance, suggesting that the menstrual cycle has no effect on verbal or spatial skills (*Neuropsychopharmacology*, doi.org/mfxs). The changes in brain region size in earlier studies may just be adaptive, says Pletzer.

However, menstruation could influence cognition differently in those who are very sensitive to hormone fluctuations or who have irregular menstrual cycles, says Liisa Galea at the University of Toronto. "These findings don't mean that these hormones don't matter for [cognition]," she says. "This just tells us that across a 'normal' menstrual cycle, we don't see these kinds of effects." ▮

Cell biology

Tiny tornadoes inside cells mix up their contents

FRUIT fly egg cells create internal tornadoes to help them develop, and these twisters may also occur in large cells of other species.

The cells of all living things contain fluid called cytoplasm, which moves around in a process known as cytoplasmic streaming. These fluid flows remain poorly understood, however.

Now, Stanislav Shvartsman at Princeton University and his colleagues have observed cytoplasm in the egg cells, or oocytes, of fruit flies (*Drosophila melanogaster*) using a microscope. The oocytes are roughly spherical and about 0.5 millimetres across – much larger than most cells. The researchers saw twister-like flows in the cytoplasm that made it circle around the cell over several minutes.

Shvartsman and his team suspected that these slow twisters were caused by protein assemblies called microtubules, which help give cells their structure and shape. Thousands of these microtubules are attached to the cell membrane, and tiny motor proteins climb along them to move cellular cargo.

The researchers used simulations to calculate the effect that these microtubules and motor proteins might have on the cells' fluid and vice versa, finding that they could closely reproduce the patterns they saw when observing live cells (*Nature Physics*, doi.org/mfxv).

"The motor is working on the microtubule: it's carrying cargo and, as a consequence, it's stirring the fluid," says Shvartsman. "Now the fluid can influence the buckling of the microtubules, and all of these together can lead to self-organisation of

"These can lead to self-organisation of a flow that spans the cell. This is absolutely remarkable"

a flow that spans the cell. This is absolutely remarkable."

To properly grow and divide, oocytes need a stage where they distribute and mix different cellular ingredients together before fixing certain elements in place. These twisters seem an essential part of this mixing stage, says Shvartsman, and they could occur in other animal egg cells that are sufficiently large.

Human egg cells are about a fifth of the size of fruit fly egg cells and are probably too small for this effect to take place, but many insects, fish and amphibians have larger egg cells where these flows may be important, he says. ▮

Alex Wilkins

Food science

Yeast tweak to raise the bar for lager

Hybridisation of yeast species in the lab opens the door to beer with novel flavours

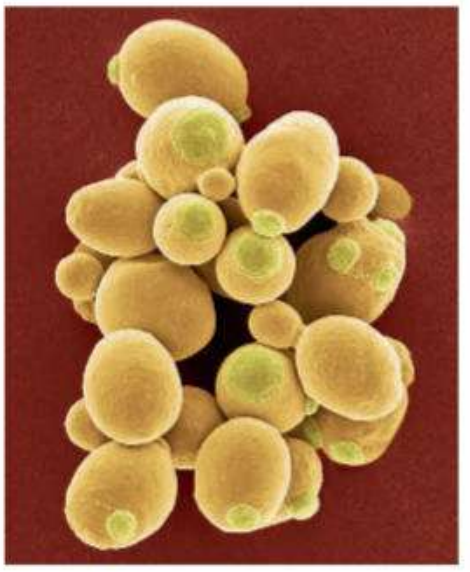
James Woodford

IT'S lager, but not as we know it. One of the world's most popular beer varieties could soon be made with a range of novel flavours, thanks to new hybrid strains of yeasts used in brewing.

"We are in the process of generating an entirely new set of strains that has the potential to significantly diversify the current lager experience," says Francisco Cubillos at the Millennium Institute for Integrative Biology in Santiago, Chile.

Most other types of beer are made with ordinary brewer's yeast (*Saccharomyces cerevisiae*). But lagers use *Saccharomyces pastorianus*, which is a hybrid of certain strains of *S. cerevisiae* and a yeast called *Saccharomyces eubayanus*. The hybridisation is thought to have happened twice in the past 500 years, probably in breweries in northern Europe. This means all lager yeasts originate from two lineages – known as the Saaz and Frohberg strains.

These lager yeasts metabolise more slowly and in colder conditions than ale yeasts, giving lager its clean and crisp taste. Ale yeast, though, has hundreds of distinct varieties, which helps to create a wider range of flavours.



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

Cells of *Saccharomyces cerevisiae* yeast, used in the production of beer and bread

The origin of the lager yeast ancestor *S. eubayanus* has long been mysterious, but in 2011, wild strains were found in the Patagonian Andes. Cubillos and his colleagues brought these wild strains back to the lab to hybridise them with *S. cerevisiae*.

The team subjected the hybrids to conditions typical of beer fermentation and examined which strains performed best in terms of fermentation and flavours. Within six months of lab-accelerated evolution, the researchers had a shortlist of new lager yeast candidates (bioRxiv, doi.org/mfxx).

Cubillos says beers made with these strains have different aromas and tastes from existing lagers. "They combine different profiles from both species, including fruity esters from both species and some light phenol notes from *S. eubayanus*," he says. "Interestingly, there is so much diversity in these two species that many novel profiles could be obtained in the future."

Benjamin Schulz at the University of Queensland, Australia, says it is an interesting idea to find the wild ancestors of yeasts used in lager and try to recreate the hybridisation that happened accidentally.

"There's a massive diversity of wild yeasts in the environment," says Schulz. "It's actually hard to know yet whether these yeasts will be able to produce different-flavoured beers, but I'm very excited to try them."

"There is so much diversity in these two yeast species that many novel profiles could be obtained"

Kevin Verstrepen at KU Leuven, Belgium, says the study is a stepping stone to commercial applications. In 2015, he and his colleagues generated new lager yeasts by crossing six different *S. cerevisiae* strains with two different *S. eubayanus* yeasts. The resulting hybrids yielded very different lager beers, he says.

"Many strains did not yield palatable beer, though – but a few did, and one of them is now used commercially at massive scales," says Verstrepen. ▮

Health

Dance mat-style game helps stop older people falling

A GAME that prompts players to step on arrows prevents falls among older people, probably by improving strength, balance and reflexes.

Our balance declines with age, with falls being a common cause of serious injury among older people. Vision problems, muscle weakness and conditions such as dementia, heart disease and low blood pressure can also raise the risk.

Now, Daina Sturnieks at the University of New South Wales in Sydney, Australia, has come up with a game called smart±step. Describing it as "arcade-like", Sturnieks says it was designed to be an inexpensive tool that can be used at home to reduce the risk of falls. It provides cognitive and motor training by prompting players to step, at varying speeds, onto targets on a wireless electric floor mat.

To put the game to the test, Sturnieks and her colleagues recruited 769 people aged 65 or over, some of whom had a history of falls. The recruits were split into three groups and they all received a workbook on how to prevent falls.

One of the groups was also told to use smart±step, while another was given an unnamed cognitive-based game, similarly designed to prevent falls, to play while seated. The latter two groups were encouraged to play their respective games for at least 2 hours a week for a year.

NEURA

The smart±step game involves moving your feet to target arrows on a mat

Those in the smart±step group fell significantly less over the year than those in the group just given the workbook. There was no overall difference between the group that played the seated game and the workbook group. However, among those with a history of falls, those who played the seated game fell less often (*Nature Medicine*, doi.org/gtdz45).

"We wanted to make the type of stepping practice that we know is important for fall prevention fun, and we were able to do that through a video game," says Sturnieks. ▮

Sara Novak

Environment

Sea creatures may eat more plastic if it is biodegradable

Chen Ly

MARINE animals may be more likely to eat biodegradable plastics than conventional ones, suggesting this form of the material may harm wildlife more than anticipated.

Millions of tonnes of plastic end up in the environment, including the seas, every year. It poses a risk to wildlife and can harm fertility and metabolism of some species. Biodegradable plastics – usually derived from organic sources such as seaweed – are touted as a possible solution to the problem. But not much is known about how marine life interacts with them.

To address this, Benjamin Mos and Sandra Powell at the University of Queensland in Australia tested how fishing lures marketed as made from biodegradable, semi-biodegradable or normal plastic fared in seawater.

Over two weeks, biodegradable lures gained or lost 70 per cent of their weight due to changes in their water content. "If fish eat the lure and it swells in the body, it could potentially block their guts," says Mos. Semi-biodegradable and normal lures showed only slight weight changes.

The researchers then exposed beach-dwelling soldier crabs (*Mictyris longicarpus*) and green paddle worms (*Phyllodoce novaehollandiae*) to the three types of lures for 48 hours. Both species almost exclusively ingested the biodegradable lures, with the crabs also eating a small amount of the semi-biodegradable lures (EcoEvoRxiv, doi.org/mfmm).

"Bioplastics by their very nature are a type of organic material, and that makes them potentially attractive as food," says Mos.

Although the full impact of bioplastics on health is unknown, they can contain chemicals that have adverse effects on wildlife, says Winnie Courtene-Jones at the University of Plymouth, UK. ▮

Technology

Ukraine will confuse GPS across nation to stop Russian drones

David Hambling

TO PREVENT Russian missiles and drones from finding their targets, Ukraine is deploying a nationwide electronic warfare system to confuse satellite navigation. Known as Pokrova, the system may already be in operation and is likely to also affect satellite navigation for people in Ukraine.

The "spoofing" system interferes with GPS and other satellite navigation systems – such as Russia's GLONASS and Europe's Galileo – collectively known as Global Navigation Satellite Systems, or GNSS.

"Much GNSS spoofing is based on simply modulating a fake GNSS signal with incorrect timing information, which starts to make things very confusing for the drones," says Thomas Withington at the Royal United Services Institute think tank in the UK.

Unlike jamming, which overwhelms navigation systems with noise, spoofing causes them to give a false location.

The remains of a destroyed drone in Ukraine in January

ANATOLII STEEPANNOV/AFP/GETTY IMAGES

Russia has been doing this for years. For example, satnav close to the Kremlin in Moscow may show drivers they are at Moscow airport. This is believed to be a Russian defensive measure.

Ukraine's nationwide system is on a much larger scale, however. Russia regularly attacks Ukraine using Iranian Shahed 136 drones with simple satellite guidance. The Shahed has a backup navigation system, but this quickly loses accuracy and so wouldn't cope with prolonged spoofing.

"The spoofing slips in fake signals which confuse the receiver, making it go crazy or directing it to an empty field instead of the target," says Withington.

Spoofing might cause all GPS receivers, including those in smartphones or cars, to have their locations offset by a small distance – making the interference difficult to spot – or may give false locations hundreds of kilometres away. This could cause inconvenience in Ukraine, but it isn't likely to make GPS-dependent devices permanently useless because the system may only be activated when there is a threat.

"I suspect that this would only be used in places and at times when they were actually under attack by drones or missiles," says Dana Goward at the Resilient Navigation and Timing Foundation in Virginia, a non-profit organisation that advocates for satellite navigation services.

Valerii Zaluzhnyi, commander-in-chief of Ukraine's armed forces, revealed the existence of the Pokrova system in November. He didn't say when it would be activated, but on 2 February, after an overnight attack, the official Ukrainian military Telegram channel announced that 11 out of 24 Shaheds had been shot down overnight. It added that "at least seven attack drones did not reach their targets and were lost in location".

"This may only be used at times when they were actually under attack by drones or missiles"

The wording of this report, and a similar one in January, may imply that Pokrova successfully spoofed the Shaheds' guidance, but no details have been given.

Withington says the failures of existing missile defence systems to stop long-range drone attacks in other countries suggest that such spoofing measures may be needed in future wars in addition to other defences. He suggests Ukraine may be leading the way.

"At this point, it may not be so much a question of what the allied nations can teach Ukraine, as what [Ukraine] can teach us," says Withington. ▮

Environment

Dire straits for the Panama Canal

Severe drought is threatening the stability of one of the world's most important shipping routes, reports **James Dinneen**

THE Panama Canal was among the defining engineering achievements of the 20th century. Since its completion in 1914, it has served as one of the world's most important shipping routes, providing the fastest way to sail between the Pacific and Atlantic oceans. But its visionary planners couldn't foresee the drastic fluctuations in water supply that would come with climate change a century later.

"The fresh water supply seemed infinite," says Matthew Larsen at the Smithsonian Tropical Research Institute in Panama. "No one at the time it was being built considered that they might someday have a limitation on fresh water."

That day has now come. For the third time in less than a decade, a shift to El Niño conditions has led to a severe drought. This, plus a recent surge in demand for passage through the canal, has created a water crisis. There is now limited water available to fill the massive locks that raise ships 26 metres above sea level so they can cross the continental divide, then lower them down on the other side. This has forced the Panama Canal Authority to restrict traffic.

In June 2023, the authority set limits for how low ships could sit in the water to avoid running aground in the canal's central Gatun Lake, which has been at record low levels since July. Some ships had to offload cargo to raise them in the water so they could get through. Restrictions have since tightened further, with traffic cut to just 22 ships a day in December, the lowest since the US invaded Panama in 1989 and the canal was closed. A rainier-than-expected November bulked up the lake, allowing a few more ships to pass through by February, but transits remain a third below normal.

BIENVENIDO VELASCO/EPA-EFE/SHUTTERSTOCK

Ships waiting to enter the Panama Canal in August 2023

22
Ships crossing the Panama Canal daily in December

197m
Litres of water for a single ship passage using the old locks

170m
Litres of water for a single ship passage using the new locks

"This is about the worst it's been," says Larsen. The resulting traffic jam – with some ships having to wait for more than a month to cross – has already had serious financial consequences for Panama and the world (see "Drain on the economy", opposite page). Things are set to get even worse over the next few months of the dry season, says Jon Davis at Everstream Analytics in the US. Restrictions may ease as El Niño conditions are expected to recede for the wet season starting in May. But in the years ahead, severe drought made worse by climate change will continue to threaten the reliability of the canal unless major changes are implemented.

At the heart of the canal's problems are its locks. They are filled using water from Gatun Lake, which eventually flows off into the ocean. This uses up a huge amount of fresh water. On the canal's older system of locks, a single ship passage uses about 197 million litres. On a newer set of locks completed in 2016 – which include several adjacent basins to reuse water – each passage uses about 170 million litres. Those are significant savings, given the new locks were built to accommodate larger ships, but this has also raised the number of ships that can pass through the canal, increasing overall water use, says Joseph Schofer at Northwestern University in Illinois.

"No one at the time it was built considered that they might someday have a limitation on fresh water"

Gatun Lake also supplies drinking water to more than 2 million people, and is tapped for agriculture and mining. Panama is one of the wettest countries on Earth, and when enough rain falls there is more than enough; sometimes there is flooding. But trouble comes when the rainy season doesn't deliver as much as expected. "Mother Nature has a really big role in the game, and it's hard to anticipate what she's going to do," says Schofer.

Droughts in the region are generally associated with the shift to El Niño conditions in the Pacific Ocean, says Steve Paton at the Smithsonian Tropical Research Institute. The three El Niños of the past decade – in 2015, 2019 and 2023 to now – all saw restrictions on the canal.

But the current drought stands out. Paton says 2023 was among the top three driest years in more than a century, and it had the driest October on record. Gatun Lake also set several record monthly lows, despite starting 2023 flush. "They started with

more water than they had ever had before and ended up with less than they've ever had before," he says.

Paton says warmer temperatures due to climate change exacerbate the drought by increasing evaporation. However, it remains uncertain what influence climate change has on the cycles of sea surface temperature behind El Niño itself, which is the main driver of the droughts. Nonetheless, he says the canal must prepare for change. "Any economic system that depends on stability in the environment needs to be really, really worried."

Drain on the economy

Around 5 per cent of all shipping routes pass through the Panama Canal each year. Trouble there ripples throughout the global economy, increasing the cost of moving goods. "Any disruption at the choke point will cause prices to rise," says Michele Acciaro at Copenhagen Business School in Denmark.

On their own, these increases probably aren't enough for consumers to notice, he says, but traffic jams in Panama exacerbate other problems already inflating prices and driving record numbers of ships to the canal, such as attacks on ships in the Red Sea.

With fewer vessels allowed through the canal each day, ships must wait longer in queues and pay steeper fees. Shipping giant Maersk has resorted to offloading some of its containers on one side of the canal and transporting them across the peninsula by train.

Others have avoided Panama entirely, extending the journey around the tip of Africa or South America, or shipping cargo between coasts on land. The longer trips and wait times boost emissions too.

The canal is even more fundamental to Panama's economy, generating between $3 billion and $5 billion in normal years, much of which goes into public coffers. That steady revenue has contributed to political stability and helped create a gleaming financial services industry in the country. The Panama Canal Authority now estimates the current drought could lead to a painful $500 million to $700 million in losses in 2024.

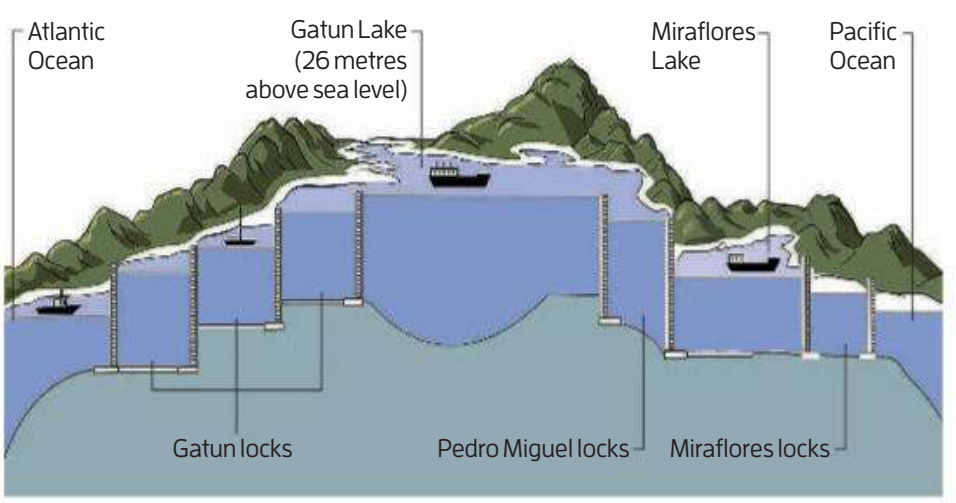
Just add water

The Panama Canal Authority has taken steps over the years to use water more efficiently. For instance, when possible, two ships move through the same lock together. New gates allow locks to be shortened for shorter ships. Water used to fill locks for descending ships is reused to fill locks for ascending ships. And the hydroelectric turbines on Gatun Lake's dam that power some canal operations were even shut off.

But the authority recognises that solving the canal's longer-term problems will require far more substantial changes across Panama's water system. "Technical solutions within the Panama Canal's jurisdiction are not sufficient to meet the growing demand for water," says a spokesperson, adding that it is working on measures "to secure a steady water supply for at least the next 50 to 75 years".

Uphill both ways

A series of locks are filled and emptied to make ship passage possible across the 80-kilometre Panama Canal



SPENCER SUTTON/SCIENCE SOURCE/SCIENCE PHOTO LIBRARY

It is likely that will mean constructing at least one additional reservoir to capture more water during the rainy season. To that end, the authority has contracted the US Army Corps of Engineers, which played a central role in building the canal, to develop a feasibility plan for what this would involve. A longstanding idea is to dam the Indio river to the west of the canal, then tunnel through the mountains to pipe water from the resulting reservoir to Gatun Lake. This could help, but it would cost billions of dollars and the prospect of flooding more land in the tiny, biodiverse country has sparked controversy.

Thousands of residents whose land would be flooded by such a reservoir have resolved to fight the project, which would require permission from the government to move forward.

With the canal spanning oceans, some have suggested pumping sea water into the locks. But that would take an enormous amount of energy and would taint the fresh water, damaging the water source for ecosystems and people. If the canal's lakes get too salty, there is even concern it would enable fish from the Pacific to invade the Atlantic and vice versa, which could be a disaster for those marine ecosystems. But there are other possibilities: Larsen says some water could be saved by fixing the leaky system of pipes that delivers drinking water to much of the country. Gatun Lake could also be dredged so ships have more space. The authority has even tested cloud seeding to stimulate more rain.

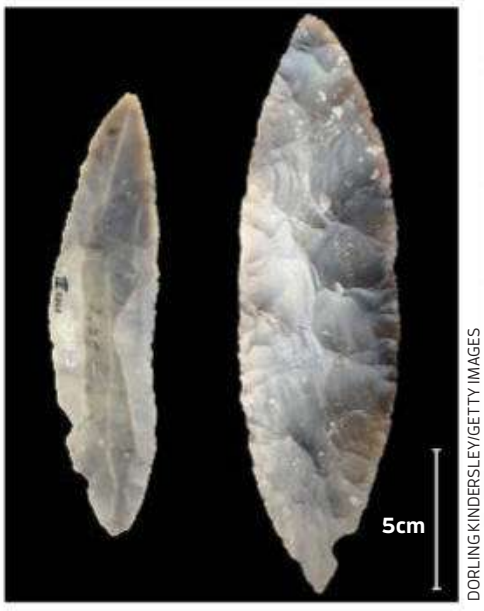
"Warmer temperatures due to climate change exacerbate the drought by increasing evaporation"

This is all enough to raise the alarm about the future of the Panama Canal. But Larsen thinks that, with so much at stake, it is "inevitable" that Panama and its ally, the US – which sees nearly half of its container traffic pass through the canal – will do whatever it takes to keep this all-important artery open. ▮

Palaeontology

A cold, early start in Europe

Evidence of *Homo sapiens* in northern Europe as early as 45,000 years ago shows our species endured icy conditions to expand across the continent, finds **Michael Marshall**



JOSEPHINE SCHUBERT, MUSEUM BURG RANIS, (CC-BY-ND 4.0)

DORLING KINDERSLEY/GETTY IMAGES

LRJ stone tools like those found at Ilsenhöhle cave in Germany (left) may have helped our ancestors hunt in a frozen landscape

WHEN modern humans first settled in Europe, they went straight to the cold north. An excavation in Germany places our species in the region at least 45,000 years ago – and supports earlier claims that our ancestors were in Britain not long after.

"These guys came into a landscape which was quite hostile," says Jean-Jacques Hublin at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. "It was like northern Finland [today]."

Modern humans (*Homo sapiens*) are the most recent hominin to permanently settle in Europe, around 45,000 years ago. Before that, the continent had been dominated for hundreds of thousands of years by Neanderthals, who vanish from the fossil record about 40,000 years ago. Modern humans and Neanderthals may have overlapped in France and Spain for 1400 to 2900 years.

"The replacement of all archaic humans by *Homo sapiens*, between 50,000 and 40,000 years ago, is something that occurred all over Eurasia," says Hublin. It was a crucial period because for millions of years there had been multiple hominins coexisting, but now only one survived.

"This is the start of one species invading all the possible habitable niches on the Earth," says Hublin. "We know it happened… but we don't know why and how."

The transitional period is mysterious. There are types of stone artefacts from the period that could have been made by Neanderthals or modern humans. One type, found in several sites in northern Europe, is known as Lincombian-Ranisian-Jerzmanowician (LRJ), and features long, leaf-shaped points that may have been fitted to spears. They had never been found in association with confidently identified hominin bones. "We had no clue who made them," says Hublin.

To find out, he and his colleagues visited several sites that had yielded LRJ artefacts. Unfortunately, previous archaeologists had damaged the sites with crude excavation methods. The one exception was a cave called Ilsenhöhle near Ranis, Germany. It collapsed thousands of years ago, so the initial excavations in the 1930s were difficult and some of the site remained undisturbed. Hublin and his team re-excavated it, digging a deep shaft down to the relevant sediment layer.

"This is the start of one species invading all the possible habitable niches on the Earth"

Buried in the sediment, they found many fragments of bone. They also re-examined similar fragments from the original excavations. By analysing the collagen protein in the bones, they determined that 13 belonged to hominins. To identify them more precisely, the team extracted mitochondrial DNA, which people inherit solely from their mothers, from 11 of the fragments. "They are *Homo sapiens*," says Hublin (*Nature*, doi.org/mfg8).

The techniques the researchers used were "top-notch", says Marie Soressi at Leiden University in the Netherlands. But she wants to see nuclear DNA as well, because it is possible the individuals were hybrids with Neanderthal fathers – which mitochondrial DNA wouldn't show. However, she says this is "very unlikely".

The timing of *H. sapiens* occupying the Ilsenhöhle fits with other evidence. Hublin's team previously showed that modern humans lived in Bacho Kiro cave in Bulgaria about 45,000 years ago. However, Ilsenhöhle is much further north.

In a second study, Hublin's colleagues used chemical evidence from preserved horse teeth to show that the climate in this part of Germany was cold at the time, especially between 45,000 and 43,000 years ago (*Nature Ecology & Evolution*, doi.org/mfg9). Again, this fits prior evidence: in 2014, Hublin's team showed that modern humans were living in Willendorf, Austria, north of the Alps, in a cold, steppe-like environment 43,500 years ago.

A third study examines animal bones from Ilsenhöhle, revealing that the cave was mostly inhabited by cave bears and hyenas (*Nature Ecology & Evolution*, doi.org/mfhb). This hints that modern humans were there only intermittently, and points to a "quick occupation by small groups of 'pioneers'", says Soressi.

Similar claims have been made for the cave of Grotte Mandrin in France: it may have been briefly inhabited by modern humans 54,000 years ago, before Neanderthals reclaimed the site.

Now that the LRJ tools at Ilsenhöhle have been associated with modern humans, it is reasonable to assume that other LRJ artefacts were also made by *H. sapiens*, says Hublin. This implies modern humans made it to Britain early on. Part of a jawbone found in Kents Cavern in England had been tentatively identified as being from a modern human and dated to about 43,000 years ago – and was found with LRJ artefacts. ▮

Space

NASA's Mars helicopter ends its mission but leaves strong legacy

Leah Crane

THE Ingenuity helicopter's flying days are over. After an astonishing 72 flights over the course of nearly three years, NASA's drone has sustained damage to one of its rotors and can no longer take to the Martian skies.

After it landed on Mars along with the Perseverance rover in 2021, Ingenuity's mission was to make five flights over about one month, to a maximum altitude of about 5 metres.

The goal was simply to prove that it was possible to fly a powered aircraft on another world, and because this difficult feat had never been attempted before, it was expected that the mission would end in a crash landing as its operators at NASA pushed the craft beyond what it was designed for. But Ingenuity exceeded expectations to an astonishing degree.

"Ingenuity absolutely shattered our paradigm of exploration by introducing this new dimension of aerial mobility," said Lori Glaze at NASA's Planetary Science Division in Maryland in a press conference on 25 January. It travelled about 17 kilometres, which was more than 14 times further than originally planned, acting as an aerial scout for the Perseverance rover.

Over the course of its 72 flights, Ingenuity reached a top altitude of 24 metres and

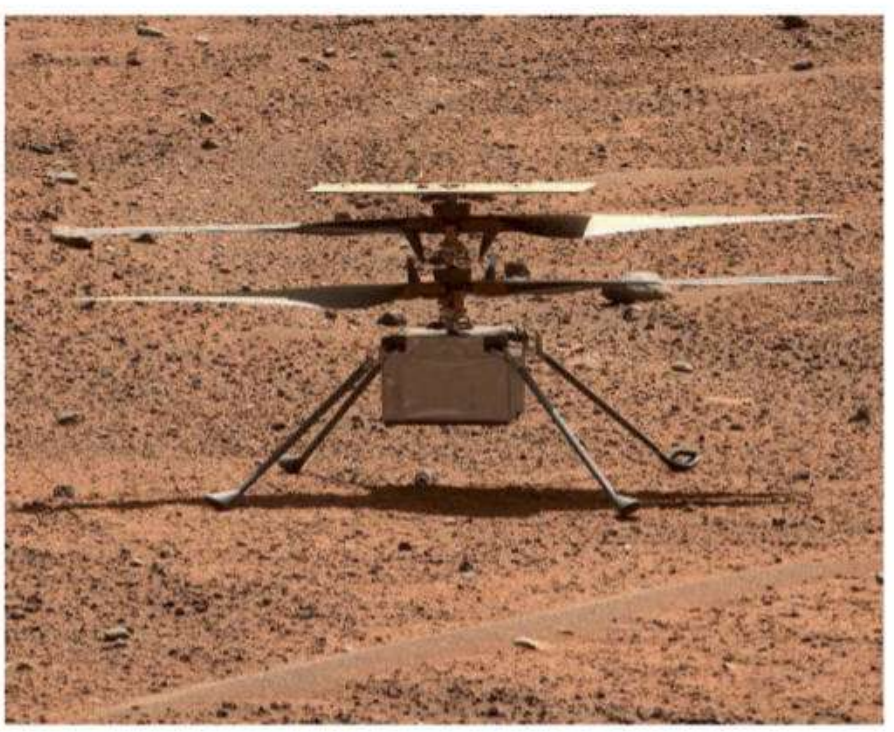
5

Number of flights originally planned for Ingenuity on Mars

72

Number of flights the drone actually managed

a maximum flight duration of nearly 3 minutes. Both of these dramatically outperformed all of the predictions that were made about the helicopter's capabilities. This proved beyond a shadow of a doubt that drones are a viable way to explore areas on Mars – and maybe other worlds as well – that are difficult or impossible to reach with traditional rovers.



NASA/JPL-CALTECH/ASU/MSSS

The Ingenuity helicopter on Mars, seen from the Perseverance rover

But on its penultimate flight on 6 January, Ingenuity had to make an emergency landing, only the third one during its entire mission. This was the beginning of the end.

On 18 January, the craft performed what would turn out to be its final flight, a simple vertical hop to determine its precise location after the emergency landing.

As it descended back towards the ground, it briefly lost contact with the Perseverance rover and controllers on Earth. When it regained contact and settled on the ground, one of its rotors was badly damaged. It isn't clear whether the communications loss led to the rotor damage or vice versa, and we may never know. Either way, the result is the same: Ingenuity has made its final flight.

But it will not be the last aircraft to fly on another world. There are plans to send similar small craft to Mars to help retrieve the samples that Perseverance has collected and stashed on the surface, and a much larger one called Dragonfly is scheduled to launch to Saturn's moon Titan in 2028.

"These missions lay the foundation for a bright future," said Laurie Leshin at NASA's Jet Propulsion Laboratory in California during the press conference. "It's so critically important that we continue to look for places, look for opportunities, to fly these things, to get that flight experience." Ingenuity was a small aircraft, but it leaves behind a huge legacy. ▮

Marine biology

Anglerfish may be so diverse because of the way they mate

Christie Taylor

A UNIQUE sex strategy may have enabled the diversity of anglerfish species that thrive today.

Chase Brownstein at Yale University and his colleagues reconstructed the evolution of the 160-plus species of deep-sea anglerfish, or ceratioids. Known for their large jaws and bioluminescent lures, ceratioids are a subgroup of the bigger order of anglerfish, which also includez bizarre bottom-dwellers like sea toads and batfish.

Using genetic sequencing, the team found that ceratioid ancestors walked on pectoral fins on the floor of the deep sea. But 55 million

DOUG PERRINE/ALAMY

A deep-sea anglerfish called the black seadevil

years ago, some began swimming in the ocean's vast bathypelagic, or "midnight", zone. There, they became much more genetically diverse than their seafloor-dwelling cousins over just 5 million years.

Brownstein's team found this rapid diversification may be due to a parasite-like reproductive strategy: a tiny male will use his jaws to attach to a much bigger female until she is ready to mate. In some species, the two even fuse. The method may give anglerfish an advantage over other deep-sea denizens that could struggle to find a mate in the bathypelagic zone.

The analysis revealed that the traits needed for this parasitism – size disparities between the sexes and an immune system that doesn't attack attaching males – predated the move to the deep ocean (bioRxiv, doi.org/mfg5). ▮

Health

CRISPR gene therapy seems to cure dangerous inflammatory condition

Clare Wilson

NINE people with a rare genetic condition that causes life-threatening inflammatory reactions appear to have been cured, after taking part in the first trial of a new version of a CRISPR-based gene therapy.

The condition, called hereditary angioedema, causes people to have sudden episodes of tissue swelling that affect body parts such as the face or throat, similar to aspects of an allergic reaction, although they can't be treated with anti-allergy medicines.

Ten people who had the one-off gene treatment, which is given directly into the body, saw their number of "swelling attacks" fall by 95 per cent in the first six months as the therapy took effect. Since then, all but one have had no further episodes for at least a further year, while one person who had the lowest dose of the treatment had one mild attack (*NEJM*, doi.org/mfgr).

"This is potentially a cure," says Padmalal Gurugama at Cambridge University Hospitals in the UK, who worked on the new approach.

Hereditary angioedema is caused by mutations in a gene that encodes a protein called C1-inhibitor, which is normally involved in damping down inflammation, part of the immune response.

People with the condition may have sudden episodes of fluid accumulation under their skin several times a month, which are painful and can suffocate them if their throat becomes blocked. The attacks can be triggered by viruses, changing hormone levels or stress.

Existing medications that can reverse the attacks work by blocking a different molecule involved in inflammation, called kallikrein, made by the liver.

People can be born without any ability to make kallikrein with no ill effects, which suggested that permanently blocking it via gene therapy would be safe, says Gurugama.

The new treatment, made by a firm called Intellia Therapeutics in Cambridge, Massachusetts, consists of genetic material designed to make cuts in the kallikrein gene. It is encapsulated in lipid nanoparticles, which liver cells take up. The treatment was given to one person in the UK and nine others in New Zealand and the Netherlands.

95%

After treatment, "swelling attacks" dropped this much

The unusual feature of this treatment is that it was administered directly into people, a method sometimes called "in vivo" delivery. "They go in for one infusion and it's job done," says Julian Gillmore at University College London, who wasn't involved in the study. "It's hugely attractive."

Most other CRISPR-based gene therapies so far have been "ex vivo", which means taking some of the person's cells out of their body, changing them in the lab and then reinfusing them, a more complex, lengthy procedure.

CRISPR-based therapies are being developed for multiple genetic conditions, with the first such treatment recently being approved in the UK and US to help people with sickle cell disease and beta-thalassaemia, two forms of inherited anaemia.

The success of the latest trial is "pretty exciting", says Gillmore. "Any disease that's caused by a mutated protein that's exclusively produced in the liver, where knocking down that protein is a good thing to do, would potentially be amenable to this technique," he says.

Environment

Tweaking aeroplane altitudes could slash climate impact

PLANES can avoid forming climate-warming contrails by changing altitude, and it would only use a small amount of extra fuel.

As much as two-thirds of the emissions from aviation come not from carbon dioxide, but from other engine emissions, such as water vapour and nitrogen oxides.

These can create the white contrails that streak behind jets in frigid, humid conditions. The contrails have a warming effect by trapping heat in the atmosphere.

Esther Roosenbrand at the Delft University of Technology in the Netherlands and her colleagues have used data on nearly 6 million flights, and temperature and humidity measurements from weather balloons, to model how flight paths would have to change to avoid contrail-forming conditions.

For about half of the flights that flew through such conditions, the researchers found that the aircraft could have avoided them with altitude changes of 609 metres or less. Such changes are already common in air traffic control. The researchers found this would require only a small amount of additional fuel and would cause few traffic issues (*Transportation Research Interdisciplinary Perspectives*, doi.org/mfgs). "Within the current structure of the airspace, a lot is possible," says Roosenbrand.

OKTAY ORTAKCIOGLU/MEDIAPRODUCTION/GETTY IMAGES

The contrails that follow planes through the sky contribute to climate change

Some airlines are already changing flight plans to avoid contrails. Last year, American Airlines flew 70 test flights using contrail forecasts and reported that the aircraft produced half as many contrails. In January, Etihad Airways said it would begin avoiding contrails by using weather models from UK-based start-up SATAVIA.

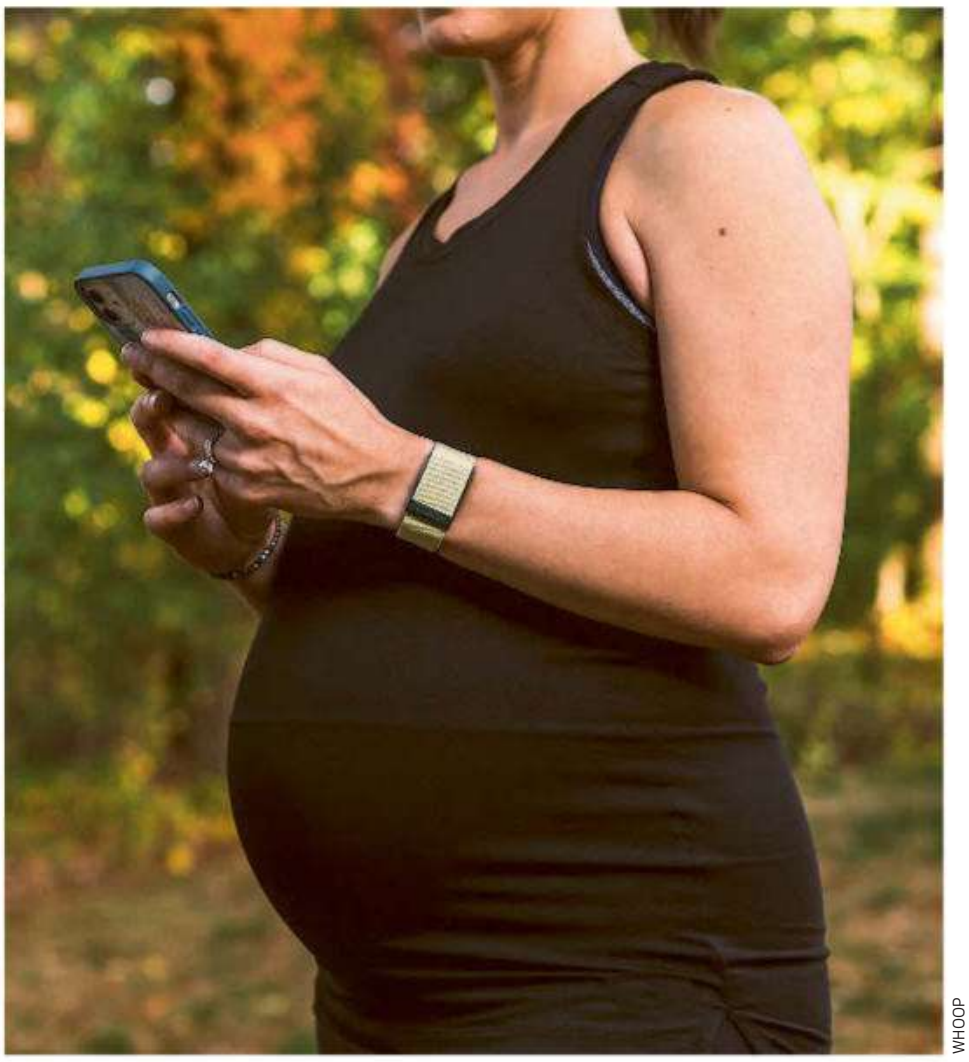
James Dinneen

Animal behaviour

Lovebirds use their beaks for swinging

PARROTS can work their way along branches by using their beaks to swing their body – a newly identified form of avian motion dubbed "beakiation".

Edwin Dickinson at the New York Institute of Technology and his colleagues unleashed four rosy-faced lovebirds (*Agapornis roseicollis*) on a branch-like runway near a ceiling. They found that each small parrot used a similar technique to navigate it: first they would grab onto the runway with their beak, and then they would pivot the rest of their body around this point of contact, allowing their feet to grasp further along the runway. They would then extend their beak forwards again – repeating the process until they reached the end (*Royal Society Open Science*, doi.org/mfkz). **Chen Ly**



WHOOP

Technology

Smart hat senses traffic light change

FLEXIBLE conductive fibre has been used to make long-lasting smart clothes with embedded computers and sensors.

Lei Wei at Nanyang Technological University, Singapore, and his colleagues placed semiconductor wire made of silicon or germanium in molten glass at about 1000°C and pulled it into fine strands. They then etched the glass away with hydrofluoric acid and replaced it with a flexible polymer coating. The researchers wove the fibre with cotton and made clothing containing electronic sensors and chips that communicate via the conductive fibre, such as a hat that senses when traffic lights change colour and passes the information to an app (*Nature*, doi.org/mfk2).

The fibres worked throughout six months of wearing, washing and drying. **Matthew Sparkes**

Health

Heart monitor can reveal risk of a birth being premature

WEARING a wrist-strap heart rate tracker during pregnancy may help doctors predict who is at risk of premature labour.

In a previous study, Shon Rowan at West Virginia University and his colleagues recruited 18 women to wear heart-tracking wrist straps from the brand WHOOP throughout their pregnancies.

All delivered at full term, with their tracker data revealing a distinct decline in heart rate variability – the fluctuation in the time intervals between heartbeats – during the first 33 weeks of pregnancy, followed by a steady increase up to birth.

Now Rowan has teamed up with Emily Capodilupo at WHOOP in Boston for a bigger study. The pair and their colleagues analysed tracker data provided by 241 pregnant people, aged between 23 and 47 years old, in the US and 15 other countries.

All the people were pregnant with a single child, born between March 2021 and October 2022. Collectively, they provided more than 24,000 heart rate variability recordings.

Those who delivered at full term had a clear heart rate variability switch at about 33 weeks gestation, an average of seven weeks before delivery.

However, for the 8.7 per cent who delivered prematurely, heart rate variability patterns were far less consistent, says Rowan (*PLoS One*, doi.org/mfkx).

The devices might one day identify pregnancies that require closer monitoring or could benefit from the administration of drugs such as steroids, which help with fetal lung development, says Rowan. Christa Lesté-Lasserre

Really brief

ORIOL ALAMANY/NATUREPL.COM

India counts its snow leopards

India's first-ever survey of snow leopards (*Panthera uncia*) has estimated that there are 718 of the big cats living in the country's six mountainous regions. That makes up about 10 to 15 per cent of the global population. The survey was conducted between 2019 and 2023 and led by the Wildlife Trust of India.

Reflective material outfoxes cameras

A synthetic material that mimics leaf structure could hide objects from cameras in green areas. Its top layer emits little infrared light, so it is hard to see with a thermal camera. The second layer emits a green hue, which could fool a normal camera in a forest (*Cell Reports Physical Science*, doi.org/mfmf).

Tusk may have been used to make ropes

A piece of mammoth ivory with four carved holes found in Germany was probably a tool for making ropes, not an artwork. It was discovered in 2015 in Hohle Fels cave and is thought to be 37,000 years old, making this the earliest known evidence of rope-making (*Science Advances*, doi.org/mfmg).

Beyond the horizon

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Witness the magic of the Northern Lights on deck, above; Northern Lights Planetarium, Star Wheel, Tromsø, top left; guests on deck MS Trollfjord, inset left

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Comment

A sense of community

Hybrid working has its benefits, but employees will be happier and more productive with more face-to-face contact, says **Robin Dunbar**

ELAINE KNOX

FOR most of us, lockdown is now just a dim memory. There has, however, been one lasting effect: hybrid work patterns. The stresses of the daily commute are no more; in its place, we have more time with the children, at the gym or shopping. It is a boon for working parents. This marks a sea change from past work practices. But has it really been the win-win situation some CEOs have claimed?

In our new book, *The Social Brain: The psychology of successful groups*, we argue that organisations – hospitals, schools, businesses, government departments – are social environments, akin to villages. They are most productive when everyone gets along, and that depends on knowing each other personally. Relationships are based on trust and a sense of obligation. This involves a great deal of face-to-face time – according to one estimate, it takes as much as 200 hours to turn a stranger into a trusted friend. If these relationships don't develop, silos and echo chambers form very quickly. Organisations become fragmented; important information doesn't get passed on, rumours spread unchecked.

Two studies of email traffic at two large organisations (one by researchers at Microsoft of their workforce, the other, which I was involved in, of a large US research university) showed that while emails to one's research group increased during lockdown, those to people in other research groups declined. This was because the casual opportunities to meet "outsiders" at face-to-face events – in the cafeteria queue, at meetings – didn't happen. More worrying, people spent much longer in online meetings than they had previously spent in face-to-face meetings. They were working much less efficiently.

The lack of daily contact causes people to lose the sense of being part of a community. In effect, they become casual employees, making them less committed and more likely to leave. During lockdown, large numbers of people joined organisations and left again without ever meeting their co-workers in the flesh.

The commitment problem isn't new. During the 1990s, many UK businesses that rented expensive London offices tried to reduce the size of their offices by getting their staff to work from home, only coming in for essential meetings. The consultants they brought in to advise them at the time warned that unless they invested in regular social events, it could lead to disengagement and inefficient working practices. It seems we have forgotten this sage advice.

More recently, it has become clear that another big problem looms. Over the past 30 years, we have been witnessing a growing pandemic of loneliness, especially in the 20-somethings moving to their first job in a big city. Most don't know anyone, and the only people they see regularly are those at work. After one multinational company tried hybrid working – well before lockdown – its younger staff put it very simply: we come into work to see our friends!

Many studies over the past two decades have shown that the single best predictor of both your mental and physical health and well-being is the number and quality of close friendships you have. Five is the ideal (including close family, by the way). So no workplace, no friends, more loneliness, more depression, more minor illnesses – and more time off work, which puts more pressure on everyone else.

The message is clear: organisations need to work much harder to create space and time at work for friendships to develop. Free onsite nurseries are a big part of that, but the adults need social space too. We need to look forward to getting to work. Businesses will have a happier, healthier and more committed workforce. In due course, they will see the benefit in their profit margins.

Robin Dunbar is a professor of evolutionary psychology at the University of Oxford

Field notes from space-time

Not on the same wavelength For most of humanity's existence, we have observed the cosmos using light, but these days photons aren't the only game in town, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

Chanda's week

What I'm reading
Geraldine Heng's The Invention of Race in the European Middle Ages *is fascinating.*

What I'm watching
I was thrilled by the classic John Carpenter movie about physicists doing things they shouldn't, Prince of Darkness.

What I'm working on
I have got a major grant proposal due at the end of the month!

This column appears monthly. Up next week: Graham Lawton

TRADITIONAL notions of data collection invoke the idea of empiricism, the notion that all knowledge comes from sensory experience. Today, we still refer to our work as empirical science, even though, at this point, there is often quite a distance between human sense-based experience and how data is collected. In both astronomy and physics, data collection typically involves complex equipment that is connected to extensive computer-based algorithms that convert the signals in the equipment into data that humans then analyse. Even so, we still treat this as a sensory process, with a heavy emphasis on what we can "eyeball" on our computer screen.

But there is a tendency to overemphasise certain sensory processes in how we practise science: what we see matters more than what we can hear or feel. Empirical practice is, after all, not just "vibes". Thus in astronomy, observing the sky using light has, for a long time, been the central practice. For most of our existence, this happened exclusively with optical observations – data collection in wavelengths that the human eye is sensitive to.

In 1800, astronomer William Herschel (who usually worked with his sister Caroline) showed that infrared heat radiation was, in fact, light at a frequency beyond the red end of the visible light spectrum. Thanks to quantum mechanics, we can now also understand that these different wavelengths of light have photons with different energies, with infrared at a lower energy than ultraviolet. Today, humans around the world observe the cosmos in a variety of apparently invisible wavelengths, from ultra-high-energy gamma rays to extremely long wavelength radio waves.

And we have learned that light isn't the only gateway to the cosmos. Over the last few decades, subatomic elementary particles known as neutrinos have become an important window on the cosmos. Neutrinos are produced in radioactive decays, which can seem pretty far out. But actually, bananas – which are high in potassium – emit neutrinos from potassium decay. (Don't worry, it is totally safe!) This same kind of process occurs in stars, star deaths like supernovae, and stellar collisions, which means that all of these phenomena emit neutrinos. Neutrinos don't interact with other matter very much, which makes observing them difficult. For this reason, the South Pole has become an important neutrino astronomy site, taking advantage of the extensive ice to house experiments like the IceCube Neutrino Observatory.

"In this new era in astronomy, we now look at the universe by feeling for vibrations in space-time itself"

Neutrinos allow us to map the cosmos using particles that aren't photons, making the entire universe an ongoing particle physics experiment that simultaneously gives us insight into the nature of neutrinos and the events that produce them. Regular readers might recall a cosmic neutrino mystery that I have mentioned before. Neutrinos come in three types – electron, muon and tau – and when they travel over long distances, they randomly oscillate between type. The non-trinary nature of neutrinos was first discovered by comparing observations of neutrinos emitted by the sun with theoretical predictions of neutrino production there.

As exciting as neutrinos are, they aren't the only non-photon game in town. In 1974, astronomers studying a binary star system observed that it was losing energy at a rate consistent with the emission of gravitational waves. Predicted by general relativity, which posits that space and time are a single entity that can curve, gravitational waves are literally ripples in space-time. The 1974 observations remained the only evidence for this phenomenon until 2015, when the Virgo Collaboration and the Laser Interferometer Gravitational-Wave Observatory (LIGO) directly detected gravitational waves from a black hole binary for the first time using vibrations in carefully designed instruments called interferometers.

So maybe at least some of science is vibes after all! Virgo and LIGO's 2015 detection inaugurated a new era in astronomy, where we now look at the universe through not just light waves and particle emissions, but also by feeling for vibrations in space-time itself. The success of LIGO also provided a strong case for the development of gravitational wave facilities. The next stop? We are going to space!

On 25 January, the European Space Agency (ESA) announced it will be moving forward with the development of LISA, the Laser Interferometer Space Antenna. ESA will work with NASA and an international group of scientists to develop this exciting new mission, which will get away from the vibrations of Earth's surface. In space, after all, no one has to wonder whether the instrument is vibrating because two black holes are colliding or because a truck drove by. ▮

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The ability to store memories and re-live each moment in detail makes an immensely important contribution to our lives. But remembering is a reconstructive process rather than a literal act of reproduction. Sensory and perceptual features of an event, and the thoughts and feelings we had when the event occurred, are assembled at the time of recall under the influence of varied biases and pressures. In this talk, Jon Simons will explain how the brain captures memories and how they are rebuilt each time they are recalled, allowing us to re-experience past events in vivid, multisensory detail.

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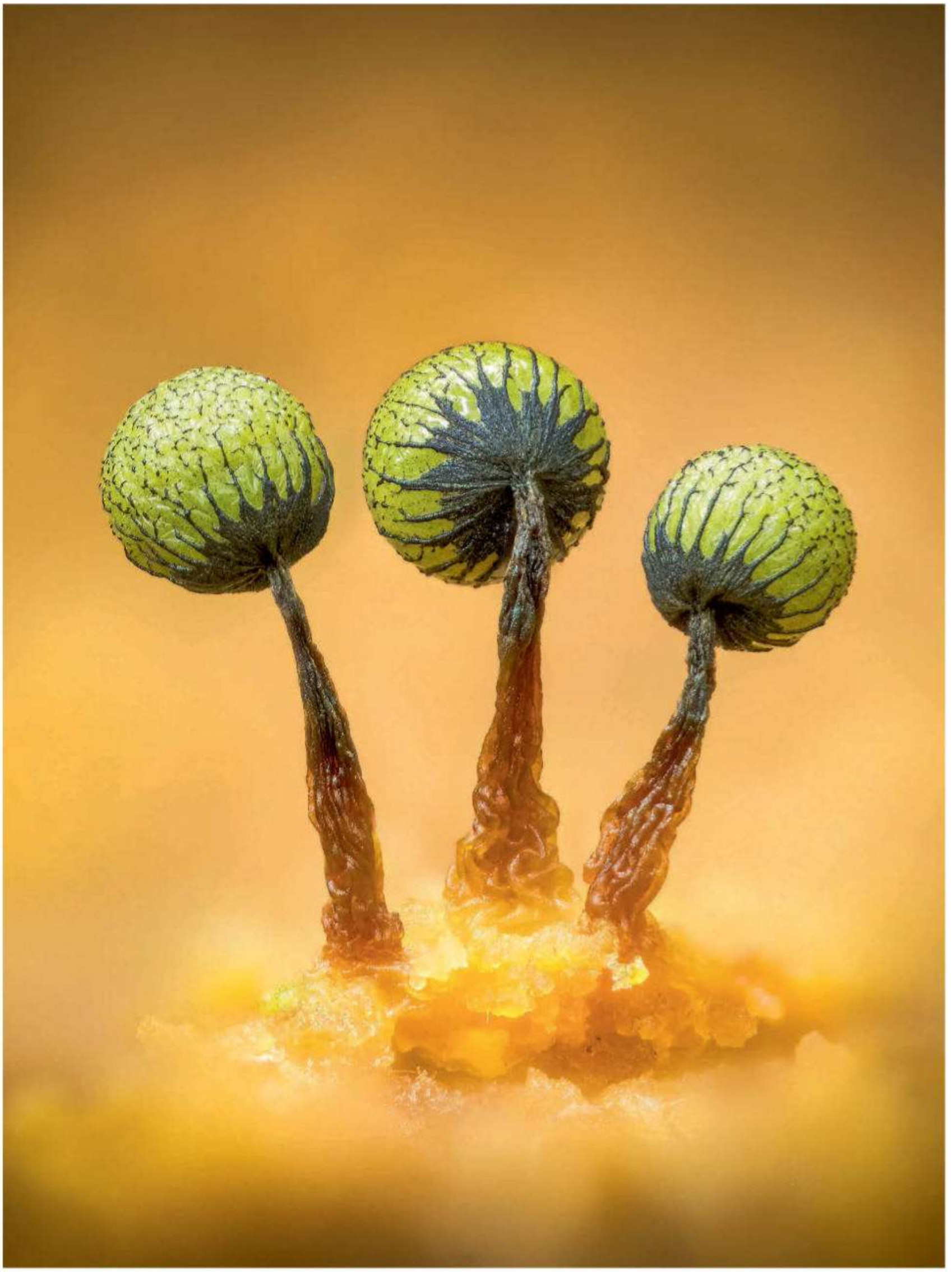

BARRY WEBB/FINALIST/THE WORLD OF FUNGI/IGPOTY

JAY BIRMINGHAM/ FINALIST/THE WORLD OF FUNGI/IGPOTY

What a fungi

International Garden Photographer of the Year

PROVING that stunning, otherworldly nature is never too far away, these images are finalists in this year's International Garden Photographer of the Year (IGPOTY) competition.

On the left is Barry Webb's composite shot of a trio of *Cribraria* slime moulds, found next to a decaying pine log in the forests of Buckinghamshire, UK, after weeks of searching. Webb's initial motivation to simply take pictures of slime moulds has developed into an "obsessive quest" to document as many as possible, he says, "always striving to produce images that capture their otherworldly beauty".

Standing at mere millimetres, these organisms were once classed as multicellular fungi, but are now considered a unique type of single-celled protozoa in their own right. It is when they merge together in the joint hunt for food – sometimes in slimy masses, other times in pinhead-like clusters, as seen here – that they become known as slime moulds.

The "heads" of these *Cribraria*, akin to tiny watermelons, are the slime mould's fruiting bodies that form when food is scarce, and from which spores are released to kick-start the life cycle once more.

A *Mycena* mushroom sprouting from a pinecone, photographed by Jay Birmingham in Dorset, UK, is shown on the right. This type of fungi can be found throughout the UK and is characterised by a bell-like cap. Both images were shortlisted in the competition's The World of Fungi category. The IGPOTY exhibition will be showing at Kew Gardens, London, until 10 March.

Gege Li

For more on fungi see feature, page 37

Editor's pick

Walk with a beep, walk with a squeak

27 January, p 14

From Phoebe Caldwell, Settle, North Yorkshire, UK

You report that beeping shoes boost walking ability in people with Parkinson's disease. Around 40 years ago, I was working with people on the autistic spectrum, one feature of which can be difficulty feeling the ground you walk on. When a colleague of my husband's got Parkinson's disease and was having difficulty walking, I suspected that he wasn't getting enough feedback telling him when his feet touched the ground.

It sounds absurd, but I gave him a couple of teddy bear squeakers to put in the soles of his shoes. He was immediately able to walk across the room, an improvement he maintained, until, being a scientist, he constructed a more sophisticated version.

How to explain and avert impending spermageddon

20 January, p 40

From Lyn Williams, Neath, West Glamorgan, UK

When it comes to how to improve sperm count, remember that if sperm were deeper inside the body, and therefore at body temperature, they would be overactive and burn themselves out. Humans have external testicles to keep sperm cooler and dormant. When they enter another body, they reach the temperature needed to get active. To help, guys should wear loose, thin underpants.

From Geoff Harding, Sydney, Australia

There may be many lifestyle factors affecting sperm count and quality. Among those not discussed are alcohol, nicotine and anabolic steroid use. The problem with correlating sperm data with these factors in a large survey is that an honest admission of the degree of consumption may be difficult to obtain. In addition, stress can have a negative influence. It may be that all the above partly contribute to lower sperm counts and motility.

From Dyane Silvester, Arnside, Cumbria, UK

Has anyone considered that the decline in sperm count and quality could be an attempt by Gaia to reduce the population of a harmful species? Perhaps Gaia is experimenting with gene drives in *Homo sapiens* in the same way that we have in mosquitoes, to make the vast majority of males infertile.

There is no need for fish waste to end up as rubbish

20 January, p 22

From Joan Zealey, Balgownie, New South Wales, Australia

You report on the issue of organic waste generated by cod fishing. When I visited the Lofoten Islands in Norway, cod waste was turned into fertiliser. A little forklift trundled back and forth all day feeding cod heads, bones and skin from the fish finger factory into a fertiliser plant. It smelled horrible, but the Lofoten people cheerfully said it was the smell of money.

Just forget the idea of supersonic airliners

20 January, p 16

From Peter Leach, Nercwys, Flintshire, UK

Why is NASA wasting time and resources on commercial supersonic flight? Is it simply a demonstration of engineering ability? Such flight will only satisfy the egos of the super-rich, while helping to trash the environment for the rest of humanity. When Concorde was conceived in the mid-1900s, there was a need to speed up the flow of information and ideas across continents, which, at the time, still relied on printed material or personal interaction a fair bit. That no longer applies. Information now flows online and personal interaction can be achieved via ever-improving virtual formats.

Not buying the quantum theory of consciousness

20 January, p 32

From Gregg DuPont, Seattle, Washington, US

Stuart Hameroff and Roger Penrose's proposal that gravitational instabilities cause "collapse" of quantum wave functions in intracellular microtubules in the brain seems like a leap. To go from that to Penrose's suggestion that each time a quantum wave function collapses in this way in the brain, it gives rise to a moment of conscious experience is a bit like a physics proof that includes the phrase "then a miracle occurs". Consciousness is simply an emergent biological result of a brain's unimaginably complex interneuronal connectome. Just biology, nerves and anatomy engaged in simple functions. No magic required.

From Sam Edge, Ringwood, Hampshire, UK

The idea that the brain may exploit quantum effects in its operation left me with a profound sense of "so what?" Consciousness, however defined, is a phenomenon of the mind, which is embodied in the central nervous system. This is a biological entity, that relies on chemical and electrical processes, which themselves arise from quantum mechanics. After all, as far as we know, everything is quantum, except perhaps gravity. Whether or not the brain uses explicit quantum effects is interesting, but makes no difference to explaining how consciousness arises unless there is a testable idea that explains the mechanism. So far, that doesn't exist.

What seems symbolic may just be utilitarian

20 January, p 12

From Gerben Wierda, Heerlen, The Netherlands

When archaeologists are confronted with observations for which they have no clear explanation, they often tend to attribute religious, or symbolic, significance, as with the straight roads between settlements found in the Ecuadorian Amazon. Might it not be that for some mundane, technical reason, such as a mode of transport, the roads needed to be straight? It all reminds me of a guide in Utah who described ancient rock paintings to me. He said signs like a hand with eight fingers were so non-factual that archaeologists had theorised these must be religious symbols. Then he said that older Indigenous people had told him an open hand signed "we come in peace" and the eight fingers meant "we are a party of eight". Just factual communication on a shared message board.

Black hole measurement could prove rather tricky

13 January, p 10

From Dave Rogerson, Tewkesbury, Gloucestershire, UK

In reading about how to solve the black hole paradox, assuming that all of the physical problems of making a measurement within an atom's width of an event horizon were overcome, then how long would it take to make such a measurement, given the time dilation effects of being so close to a supermassive black hole?

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What diets really say about us

The story of how Jacqueline Alnes fell under the spell of "fruit-only" dietary influencers shows how modern life can make us vulnerable, says **Elle Hunt**

Book
The Fruit Cure
Jacqueline Alnes
Melville House Publishing

SYLVIE ROSOKOFF

Jacqueline Alnes's symptoms have now largely receded

WHEN Jacqueline Alnes was 18, and in her first year at a US college, she was a talented athlete and runner. Two years later, she was using a wheelchair and largely confined to her house following the onset of a debilitating illness.

After collapsing on the running track, Alnes started regularly losing control of her limbs: her vision would swim, her head loll and then she would keel over. Successive doctors found no obvious cause for concern. Alnes was told she seemed to be fine.

Then, abruptly, she would lose the ability to speak, able only to repeat random words or make guttural sounds. When she came to, she had no recollection of what had happened to her.

These terrifying symptoms persisted, forcing Alnes to withdraw from competitive athletics, but they proved hard to diagnose. Tests of her heart, vision, blood and brain returned normal results. Anti-seizure medication alleviated her symptoms for a year, but made her depressed; when she stopped taking these drugs, under medical supervision, her mysterious condition returned, redoubled.

For Alnes, the trauma of losing control of her body, exacerbated by a lack of understanding among her teammates and routinely dismissive treatment by doctors, amounted to a crisis not just of health, but of identity. "My entire self-worth hinged upon my ability to run well," she writes in *The Fruit Cure: The story of extreme wellness turned sour*. And as the title suggests, she was prepared to take drastic action to win it back.

Today, Alnes is an author and assistant professor of creative writing at West Chester University in Pennsylvania, and although her illness remains undiagnosed, more than a decade of management has seen her symptoms largely recede.

"Alnes reveals many ideas about nutrition to be cloaking colonial-era beliefs about racial and sexual impurity"

But back in 2012, she was desperate. Between frequent trips to the neurologist, she sought answers online, leading her to discover "Freelee the Bananagirl", "Durianrider" and their online forum "30 Bananas A Day".

Freelee and Durianrider (real names Leanne Ratcliffe and Harley Johnstone), an Australian couple and extreme "raw vegans", were online influencers throughout the early 2010s, espousing the benefits of a predominantly fruit diet. Alnes was among hundreds of thousands who turned to them for help with ill-health or weight loss.

While Ratcliffe, Johnstone and "30BaD" (as the forum was known for a time) have since largely retreated from public view, their legacy is inescapable in the proliferation of dieting content on social media: much of it highly prescriptive and too restrictive to be considered healthy, and possibly actively harmful.

In *The Fruit Cure*, Alnes delves into the personal challenges and structural failings that left her vulnerable to 30BaD's regimen, and the unrelenting, culturally charged drive to diet – despite all the evidence against doing this.

In her accomplished and comprehensive, yet compassionate, book, she interweaves her own story with that of Ratcliffe and Johnstone, whose self-proclaimed "fruitarian" paradise finally fizzled out in 2016 with the acrimonious end of their relationship.

But this instinct to heal, even "purify" ourselves of all society's ills, by changing how we eat (or, more pertinently, don't eat) is far from a modern phenomenon, as Alnes shows. Her research into the first vegetarian organisations of the 19th century and the "mono diets" (such as eating only grapes) trumpeted from the early 1900s onwards shows just how little has changed in our moralising around food.

Indeed, Alnes reveals many pernicious ideas about nutrition (such as "clean eating") to be cloaking outdated and derided colonial-era beliefs about racial and sexual impurity. The parallels with modern diet culture are myriad and often unsettling. Yet, still, dietary influencers of today are often not held accountable for adverse effects.

Alnes's interweaving of personal experience, diligent reporting and wide-ranging cultural history make *The Fruit Cure* an engaging, clear-eyed, often vulnerable read that goes a long way to make sense of why so many of us seem to find the simple act of eating so fraught. She dangles no quick fixes or silver bullets. But, as she knows from her own long, hard road to good health, that is precisely the point. ▮

Writer Elle Hunt is based in Norfolk, UK

On the origin of extinction

A hopeless Victorian quest to find the great auk may have fuelled modern concerns about extinction and conservation, discovers **Tom Tierney**

Book

The Last of Its Kind
Gísli Pálsson
Princeton University Press
Out now in the US; in the UK 2 April

IN 1858, John Wolley and Alfred Newton, two British scientists, travelled to Iceland to study the great auk, a large, flightless seabird. They hoped to observe the bird in its natural habitat and perhaps bring home an egg, a skin or a stuffed bird to add to their collections.

This didn't quite work out, as we discover in *The Last of Its Kind: The search for the great auk and the discovery of extinction*, an engaging book by anthropologist Gísli Pálsson. He dates modern concerns about extinction and the need for conservation to their work. This gives their effort and his book true relevance for today – and a new role for both men.

In the 19th century, extinction was seen either as an impossibility or a natural part of life. Charles Darwin was aware many species had died out over the centuries and this understanding was central to his thinking on evolution. But he believed it was always natural and inevitable, and happened slowly.

When Darwin's breakthrough paper with Alfred Wallace, outlining the concept of natural selection for the first time, was read to the Linnean Society in July 1858, Wolley and Newton were still in Iceland. They were slowly coming to terms with the fact that the great auk had disappeared – and human activity was largely to blame.

The two men may not have seemed like natural companions. Pálsson paints vivid pictures of them. Wolley was sociable, restless and athletic, a strong swimmer and a skilful climber, one of the few who had managed to climb Mont Blanc in the Alps. By contrast, Newton was an introverted loner. A childhood injury limited the use of one of his legs, so he used a cane to walk.

But they were drawn together by natural history – in particular, a shared interest in the great auk. They had seen relics of these fascinating creatures, but longed to see them in the flesh, as Pálsson recounts, bringing to life a very 19th-century passion for exploration and first-hand experience. The two worked on a plan to travel together to Iceland to find some.

They journeyed to the coastal town of Kirkjuvogur, where their host, Vilhjálmur Hákonarson, was in charge of the local fishing boat and was the man most likely to get them to the inaccessible island of Eldey.

They knew it would be hard to land and they would be lucky to find great auks. But it was the last place the birds had been seen, when a breeding pair had been killed 14 years earlier. Pálsson captures their disappointment when bad weather prevented their journey, and explains how the ornithologists had to settle for gathering information from locals who had some memory of seeing and hunting the birds.

They told of a bird that, on land, liked to look carefully to the left and right with its neck outstretched, before running forward with tiny steps. In the water, however, it swam with great elegance and speed, using the tiny wings that looked purposeless in the air to control its motion.

The two men left Iceland after three months, having failed to see a great auk, but still hopeful that the bird survived, somewhere. Wolley died tragically the following year, and it was up to Newton, seven years later, to reluctantly accept that the bird was now extinct.

Greak auks had once been hunted for food and for the oil that could be extracted from their carcasses. But it was the market for their eggs and stuffed remains, created by scientists and collectors, that had led to their demise – an irony not lost on Pálsson.

Newton became a campaigner for animal protection, and Pálsson makes a good case for remembering him as a pivotal figure in the history of our relationship with other species, and in understanding how our behaviour can affect them.

Tom Tierney is a writer based in Dublin, Ireland

The great auk was driven extinct by a scientific market for its eggs and stuffed remains

OSCAR DOMINGUEZ/ALAMY

New Scientist *recommends*

Matthew Sparkes
Reporter
London

I have been reading **Surely You're Joking, Mr. Feynman!**, a bite-size collection of anecdotes from the brilliant and eccentric physicist Richard Feynman (pictured). I was reminded of it while watching **Oppenheimer**, as he was also part of the Manhattan Project.

Stuck in a desert with not enough to occupy his amazing mind, Feynman took to cracking safes full of nuclear secrets. He would snaffle classified reports and return them later, or leave cheeky notes inside. Security must have loved him. But his compulsion to understand absolutely everything is infectious.

I am also enjoying **Clickspring**, a YouTube channel where a hobbyist engineer uses only tools available to the ancient Greeks to build a replica of the Antikythera mechanism. This "computer" could predict the movements of the sun, moon and planets. It is fun to speculate what its makers might have gone on to achieve – and why they didn't.

BO ARRHED/ALAMY

When the rain came

A new film set in a flooded London looks to the individual, emotional struggle of a mother caring for her newborn, says **Katie Smith-Wong**

Film

The End We Start From

Mahalia Belo

On general release in UK cinemas
US release to be announced

SIGNATURE ENTERTAINMENT

The Woman (Jodie Comer) and her baby must survive floods

ACCORDING to Thames Water, the UK's largest water and wastewater company, parts of London experienced a month's worth of rainfall in a single hour in July 2021, affecting over 2000 properties. And with reports estimating that several areas of the city will be below sea level by 2030, this poses a key question – are UK cities prepared for excessive flooding?

This question is echoed in *The End We Start From*, directed by Mahalia Belo and starring Jodie Comer. Adapted from the book of the same name by Megan Hunter, the film follows an unnamed character, Woman (Comer), who fights for survival while caring for her newborn baby when the UK is hit by excessive flooding.

Since the beginning of 2024, the UK has experienced particularly stormy weather. In January, storms Henk, Isha and Jocelyn badly affected many parts of the UK, including the North, the Midlands and Northern Ireland. They also disrupted London, as the city saw high levels of rainfall that closed whole sections of the London Underground.

Hyped-up versions of crises such as these would form the premise of typical Hollywood blockbuster disaster films such as *The Day After Tomorrow*, or the somewhat lower-key British-Canadian film *Flood*, in which the narratives revolve around the survival of a star-studded cast of protagonists and the general theme of escaping danger.

The End We Start From, however, brings a more grounded, everyday approach to the idea of surviving a natural disaster, by focusing on how ordinary people navigate the aftermath of a crisis. Whether it is through their immediate actions or how they adjust to an altered normality, Belo's debut film explores the emotional turmoil such an emergency can create at an individual level – combined in the Woman's case with the first exhausting months of motherhood.

Rather than have audiences immediately dropped into such a disaster, Belo and screenwriter Alice Birch slowly build the extent of the crisis in parallel with the Woman's journey as a mother. The film teases the danger of excessive rainfall through one of its calmer and seemingly more mundane moments, until danger hits – quite literally – as the flood waters crash into the Woman's home. Within the first 10 minutes, Belo effectively establishes the precariousness of the situation and the fear of what can happen on a rainy day.

The Woman's hazardous journey evokes an underlying sense of terror about the unknown, especially when desperation and selfishness replace common decency and compassion. The changing situation forces the Woman to shed her naivety about human kindness, and – thanks to Comer's gripping performance – she exudes frustration, despair and determination.

"The shots of a flooded London are especially striking, exposing how unprepared this version of the UK is"

As the world currently adjusts to a post-pandemic reality, the idea of surviving such turmoil and remembering the "before days" will resonate with audiences. The supporting characters – such as those played by Katherine Waterston, Benedict Cumberbatch and Gina McKee – help to reinforce this concept, as some of them would rather remember their past while others would prefer to move on.

This offers the Woman the familiar moral dilemma of whether to risk everything or do nothing, leading the narrative in an empowering direction that sees her use her initiative to survive, rather than lean on others.

Belo creates an intimate portrayal of the Woman's growing struggles while also incorporating sensitive external shots to convey the breadth of the crisis and its environmental impact.

For instance, the depiction of a flooded London, where water levels are nearly as high as an old-school double-decker bus (around 4.4 metres), is especially striking because it exposes clearly how woefully underprepared this version of the UK is in the event of such serious flooding – and the sheer enormity of what it would take to get the country back to normal.

Overall, *The End We Start From* has an intriguing concept at its core, one that it explores with great sensitivity and nuance. It also reinforces its female-driven narrative with a sense of hope and strength, anchored by Comer's powerhouse performance. ▮

Katie Smith-Wong is a film critic based in London

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NewScientist

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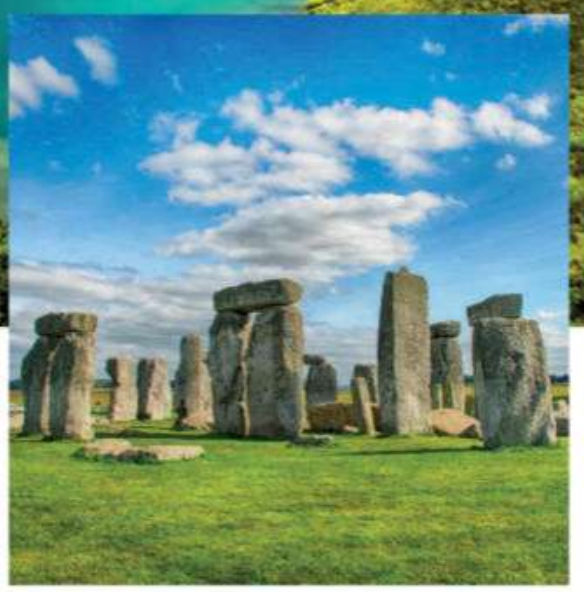

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The shape of reality

The hunt for a final theory of physics appeared to have stalled. But new ideas emerging from a wild landscape of geometry are reinvigorating the hunt, says **Michael Brooks**

SKIZZOMAT

WHAT if there were a perfect board game? Some combination of boards and pieces and rules – maybe with a few yet-to-be invented additions – that would create an unsurpassable experience, the only board game anyone ever wants to play?

That's how physicists feel about the theory of everything, a putative "final" framework that would explain all reality in one fell swoop. This is the ultimate goal for physics, with Stephen Hawking once memorably writing that to find it would be to know "the mind of God".

It is an audacious mission, so much so that some people consider it quixotic. At this stage, there can be no doubt that breaking reality down into ever more fundamental pieces hasn't quite worked. But the potential payoff of a final theory is so huge that some physicists doggedly refuse to give up, and now they are pivoting towards a radical new approach.

Since a theory of everything has to explain all the constituent parts of reality, including space and time, the idea is that we must start from an even more basic premise. That is why a spate of new would-be final theories aren't grounded in physics at all, but in a wild landscape of abstract geometry. Perhaps the ultimate scientific truth lies within the mathematics of a metaphysical jewel that computes the universe, or a shimmering tapestry of triangles and tetrahedrons?

That might strike you as outlandish, but it makes sense to Peter Woit, a mathematician at Columbia University in New York. "Our best theories are already very deeply geometrical," he says.

To be fair, physics has taken us quite a distance already. Survey the field today and you see a handful of grand theories that cover a generous slice of reality. Albert Einstein's general relativity explains how massive objects deform space-time to generate gravity. Quantum theory peerlessly characterises behaviour on the smallest scales. Modern cosmology provides an account of how the universe began and evolved. Thermodynamics explains how things such as heat, work and energy operate. Yet these are all separate pillars, each dealing with one aspect of reality. They are the Monopolies and the Scrabbles of physics – each fabulous in its own right, but not the perfect game.

A theory of everything would, for starters, explain all of what those pillars encompass in one self-contained framework, potentially even a single equation. It would also have to contain explanations for the outstanding problems in physics, including dark matter and dark energy, two ingredients that we believe must be present in the universe, but which we have yet to unmask.

You might say the search for such a theory originated 26 centuries ago, when the Greek philosopher Thales of Miletus proposed that everything is ultimately made of water. That was the start of the endeavour we now call reductionism, which aims to discover what the most basic parts of reality are.

We probed down past molecules, atoms, protons and neutrons and eventually found quarks, the ghostly components of atomic nuclei. All of which delivered the "standard model" of particle physics, our current best, albeit incomplete, explanation of reality, which has been backed up by experimental evidence for decades. Perhaps, then, one way to find a theory of everything would be to persist with reductionism.

Absolute unity

Alternatively, maybe the ultimate framework of reality can only be obtained through an approach called unification. Looking back over the development of modern physics, you can see it as a series of occasions on which two things we thought were separate turned out to be the same. Magnetism and electricity aren't different beasts – they are both explained by electromagnetism, as James Maxwell suggested in the 1860s. Space and time seem separate in our everyday lives, but Einstein's great breakthrough was to show they are inextricably linked in space-time, the board on which reality plays out.

Take unification to its logical conclusion and maybe you end up with a "grand unified theory". This may not be a fully fledged theory of everything – in the sense that it may not explain unknowns like dark energy – but it might be close.

Sometimes both approaches can combine. String theory, along with its parent, M-theory, is the best-known candidate for a final ›

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theory. It is perhaps the ultimate in reductionism, positing that the most fundamental component of reality isn't the quark, but one-dimensional strings. One reason it has generated so much excitement over the years is that it also promises to take us further down the road to unification. In the early 20th century, string theorists found their ideas led them to a particle that seemed to create a quantum version of gravity, hinting at a way to reconcile two of those separate pillars of physics, general relativity and quantum theory.

Tied in knots

However, string theory hasn't proved as successful as its proponents hoped. The main problem is that it doesn't lead to one unique description of the universe, but 10^{500} different possibilities – more options than there are atoms in the universe. "It can be a theory of everything, but probably it's a theory of too much," says string theorist David Berman at Queen Mary University of London.

Increasingly, physicists sense they need to approach this whole project differently. And because a final theory must explain the fundamentals, including space, time and everything within it – including how they all relate to each other – some reckon it would be natural to start from an even more basic place: with geometry.

Geometry is, after all, the study of the relationships between lines, surfaces and edges. Many of us wrestled with the geometry of triangles and other shapes at school, but the relations don't have to exist in a physical space. They can be entirely abstract. If we are looking for the simplest possible starting point to explain everything, this is a decent candidate.

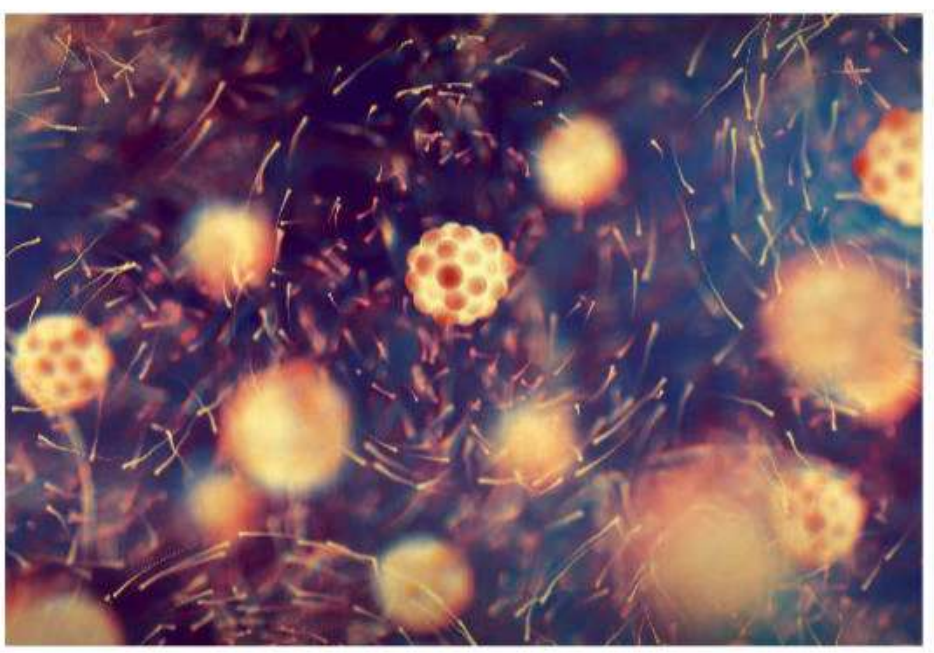
One exploration of abstract geometry that might lead us to a final theory comes in the form of a mind-boggling mathematical object known as the amplituhedron, which appears to describe a sizeable chunk of fundamental particle physics. Think of it as a kind of multifaceted jewel. With a real jewel, white light goes in, and the geometry of the light source, crystal structure and observer combine to give the experience of colours, shimmers and sparkles. In the amplituhedron, think of the light going in as the mathematics describing one particle. What emerges, thanks to the geometry of this imaginary crystal, is mathematics that describes things that happen to that particle, for example if it were to collide with something else. This is crucial, foundational stuff. "The amplituhedron approach reformulates the fundamental laws of nature in a geometric language," says Jaroslav Trnka at the University of California, Davis, who pioneered the amplituhedron idea about a decade ago with Nima Arkani-Hamed at the Institute of Advanced Study, New Jersey.

What they found is that turning to geometry is a way to shortcut the daunting maths of quantum field theory, or QFT, which uses a clutch of mathematical abstractions to pin down the way nature acts so that we can make predictions about what fundamental particles exist and how they behave. Sometimes, QFT's abstractions are extremely cumbersome and the calculations too time-consuming to run, even on the supercomputers available to the world's best physicists. The amplituhedron gets around this because, as well as being jewel-like, it is also computer-like. Put simply, the amplituhedron's geometry – all those facets and edges and corners – mean that what goes in is processed like information in a computer. "Here the mathematics is fundamental, and physical properties of particle interactions are a consequence of the intricate geometry," says Trnka.

The amplituhedron isn't a theory of everything: it only describes a subsection of known particle physics. But it is tempting to wonder if it might lead us towards something deeper. Adopting novel mathematical tools has often been vital for creating new insights in physics, from the calculus that enabled Isaac Newton to describe the motions of the planets to the use of "Lie groups" that led Murray Gell-Mann to predict the existence of quarks. Trnka thinks the amplituhedron approach might enable us to go even further. "One can speculate that whatever the correct theory of everything is, it would be naturally described in the amplituhedron language," he says.

However, even the amplituhedron might not be as fundamental as it gets. In mathematical terms, it is actually constructed from several geometrical ingredients, one of which is called a twistor – and, incidentally, this turns up in another contender for a theory of everything.

The twistor was first dreamed up in the late 1960s by the University of Oxford mathematician Roger Penrose. He saw it as a tool that might help unite quantum theory with gravity. Twistor theory essentially seeks to encode the universe's events – a particle collision, say – as twistors, whose interactions give us the physics we observe. But twistors can be broken down, mathematically speaking,



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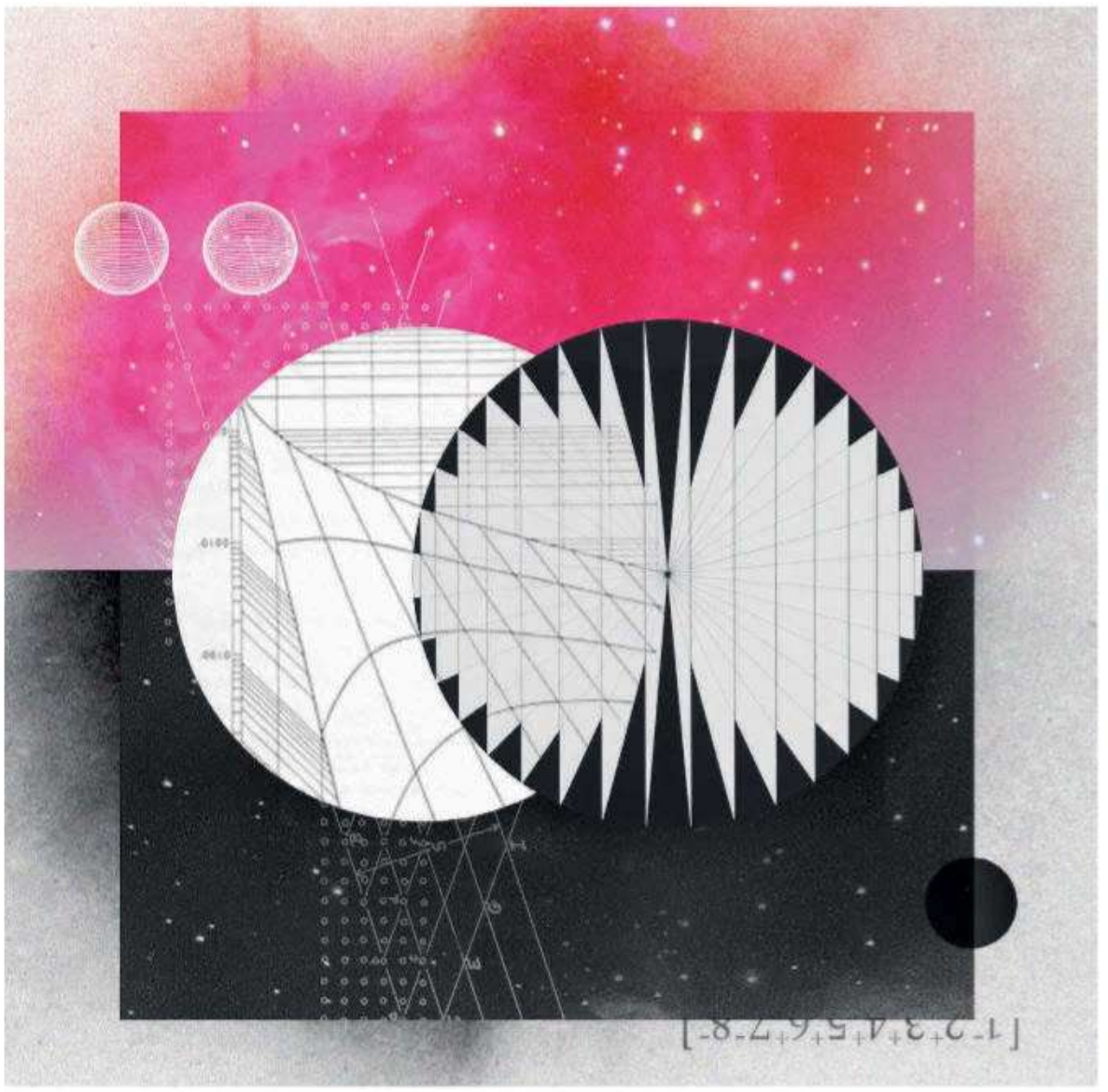
Atoms were once seen as the most basic building blocks of reality – but not any more



"Perhaps the ultimate truth lies in a metaphysical jewel"

into yet more geometrical objects called spinors. These come in two varieties, referred to as left and right-handed spinors.

Woit is using spinors and twistors to create what he hopes are the foundations of a theory of everything. He describes space and time using vectors, which are mathematical instructions for how to move between two points in space and time – that are the product of two spinors. "The conventional thing to do has been to say that space-time vectors are products of a right-handed and a left-handed spinor," says Woit. But he claims he has now worked out how to create space-time from two copies of the right-handed spinors.

The beauty of it, says Woit, is that this "right-handed space-time" leaves the left-handed spinors free to create particle physics. In quantum field theory, spinors are used to describe fermions, the particles of ordinary matter. So Woit's insights into spinor geometry might lead to laws describing the holy trinity of space, time and matter.

The idea has got Woit excited. He has spent most of his career looking at other ideas, thinking they will go somewhere, and being disappointed. "But the more I looked at twistor theory, the more it didn't fall apart," he says. "Not only that, I keep discovering new ways in which it actually works."

Sticking points

It isn't that Woit believes he necessarily has the answers. But, he says, it is good to know that, despite the long search for a theory of everything, there are still new possibilities opening up. And a better, if not perfect, theory has to be out there, he reckons, one that at least deals with sticking points like dark matter. "If you look at what we have, and its problems, you know you can do better," he says.

Berman agrees there is scope for improvement, but feels string theory is still the best candidate. "I just don't see anything else with that level of complexity and achievement," he says. But he adds that there is room for other approaches and we should encourage them: "We certainly shouldn't throw stones at each other."

Part of the problem is that these ideas are so complex that it is hard for outsiders – even people working on alternative theories of everything – to appreciate their potential. It is also difficult to test them. In addition, there is the question of whether it is even reasonable to think the universe can be explained in one principle or even a single set of equations. Arguably, the existence of such a theory is just a hunch, which could make the hunt a fool's errand. "The theory of everything is just an idea," says Renate Loll at Radboud University in the Netherlands. "It may not be the right way to think about physical theories. It may be that you're not able to write down some magic formula from which everything else follows."

Even so, Loll thinks it is worth looking at novel and ambitious ways to describe the universe. Her approach, also rooted in geometry, is called causal dynamical triangulation, or CDT, and it starts with simple shapes. Just as pentagons and hexagons can be stitched together into a soccer ball, Loll connects triangles and tetrahedrons to create a surface with a curvature that mimics Einstein's space-time. She supplements this with a mathematical scheme that gives a clear cause-and-effect structure to events that occur within her space-time to reflect the causality we see at work in our universe. It is, you might say, another way of creating the board and the instruction booklet for the game of reality.

Loll's framework gets a good bit more sophisticated. Use not one sheet of space-time, but an ensemble of many layers, and she can recreate some features of quantum theory, which is encouraging. And, even if it is early days for the idea, Loll reckons there will be ways to probe it with real experiments connected to the radiation left over after the big bang. "We are getting towards observables that could conceivably have left some imprint in the cosmic microwave background radiation." ›

"Quantum holonomy starts with pure algebra, it's about as abstract as it gets"

Such testability is important, says Jesper Moller Grimstrup, a Danish mathematician who has recently eschewed traditional academic environments in order to be able to work on non-mainstream ideas. His approach to a final theory, developed with Johannes Aastrup, a mathematician at the University of Hannover in Germany, is called quantum holonomy-diffeomorphism (QHD).

All from nothing

While others began with more or less elaborate shapes, Grimstrup and Aastrup start about as abstract as it gets, with pure algebra. QHD encodes some basic features of ordinary, empty space in a set of mathematical operations: an algebra. Grimstrup and Aastrup then deduce a "configuration space" from the algebra. This space, which has an infinite number of dimensions, contains all the different ways some object – Grimstrup refers to it as "stuff" – can be moved around in the space. Configuration spaces aren't a new idea; they are entirely standard in quantum field theory. "What is new in our approach is the way that we consider the geometry of this configuration space," says Grimstrup.

The pair start with their configuration space, which is a description of space-time. But as they analysed the mathematics, they found the mathematical signatures of fermions encoded within the geometry. "What we are doing is simply considering the geometry of that space," says Grimstrup. "By doing this, we relatively easily obtain the basic building blocks of both general relativity and quantum field theory. So the 'stuff' is there, but not as a part of the foundation."

Perhaps even more exciting is the fact that something akin to Einstein's vision of gravity appears too. "Gravity plays no role in our construction in its initial form: gravity in this construction is emergent," says Grimstrup. It isn't yet clear whether this is actually general relativity. "We see promising signs, but we need to check a few things before we can say that with certainty."

In essence, the duo start with the maths of empty space and see the building blocks of those two pillars of physics, quantum field theory and general relativity, emerge naturally. On the face of it, that is a remarkable achievement and the duo have recently published their framework in its most complete form yet. A final theory it isn't, but with its simple foundations, it does at least have the required characteristics.

Testing these ideas remains a long way off, says Grimstrup, but it isn't looking impossible. One reason for his optimism is that the QHD geometry gives rise to a phenomenon called a dynamical ultra-violet regularisation. This manifests as something that, at very high energy conditions such as those in black holes, works against gravity. Could it be that this anti-gravity style force explains the dark energy that is accelerating the expansion of the universe? "We have not looked closely at this yet, but I think this must have some cosmological implications," says Grimstrup. "I can't help but wonder if it might be related to dark energy."

It is speculation at this point. That said, when Woit – who has long been known as an arch cynic – is excited about the search for a theory of everything again, maybe all bets are off. Playing with twistors has changed him, he says. "I've spent most of my life saying that I don't have a convincing idea and I don't know anyone who does. But now I'm sending people emails saying: 'Oh, I have this great idea'."

Woit says it with a grin, acknowledging the hubris of thinking that maybe, after so many millennia, we might finally have cracked the universe open. "Of course, it may be that there's something wrong with me," he says. "Maybe I've just gotten old and just lost my way." ▮

Michael Brooks is a *New Scientist* consultant. His latest book is *The Maths that Made Us*

Microscopic marine fungi are abundant, with around 2000 species found to date

DAYARATHNE MC ET AL. (2020)

Fungi ahoy!

The oceans, it turns out, are teeming with fungi and they could help solve some of humanity's biggest challenges, finds **Graham Lawton**

TAKE a walk along a seashore almost anywhere in the world and you will probably see colourful patches of life growing on rocks, sea walls and driftwood. These are lichens, mutualistic partnerships between fungi and algae. In Britain, that might include the brightly coloured orange sea lichen and the yellowish maritime sunburst lichen, plus many other drabber species.

Lichens are usually seen as land-living organisms and, indeed, the vast majority are, growing ponderously on inland rocks, tree trunks, leaves and soil. But coastal ones aren't accidental vagrants from the land: they are marine-adapted species found only on or very near the shore. Until recently, they were thought to be outliers in the almost completely landlubbing kingdom of the fungi. Not any more. "In every marine ecosystem we look at, we find fungi," says Michael Cunliffe at the University of Plymouth, UK.

The study of marine fungi is now mushrooming, though their exact role and importance in marine ecosystems remain something of a mystery. Nevertheless, there are high hopes that they could help to rescue us from two of the great scourges of the 21st century: antibiotic resistance and plastic pollution.

The existence of marine fungi has been known for many years. The earliest descriptions were published in the mid-19th and early 20th centuries, but these were largely ignored by mainstream mycologists. The species discovered were mostly near-shore inhabitants of seaweed roots and driftwood, a niche that seemed so, er, nichey as to not warrant much attention. They were also dismissed as refugees from the land that had somehow eked out a life in seawater.

In 1944, however, renowned palaeontologist Elso Barghoorn proved otherwise: yes, some land and freshwater fungi can also grow and breed in seawater, but some are obligate marine species, meaning they can only live and reproduce in this environment. Still, such discoveries barely moved the mycological dial.

There was another minor surge in interest in 1979, when Jan and Erika Kohlmeyer at the University of North Carolina at Chapel Hill published a book called *Marine Mycology*. ›

They, along with Brigitte Volkmann-Kohlmeyer, had spent years scouring the world's beaches for bits of driftwood and gently teasing fungi out of them. In total, they collected 25,000 specimens, including 149 new species of obligate marine fungi, which are now deposited in the archives of the New York Botanical Garden. "It's beautiful, exquisite work," says Cunliffe. Nonetheless, the study of marine fungi remained a backwater.

Then along came molecular analysis, and a new porthole on discovery was opened. The Kohlmeyers had relied on the old-school method of collecting fungi in the field and culturing them in Petri dishes. This works up to a point, but many groups of fungi can't be cultured, especially those that form mutualistic or parasitic relationships with other organisms. Molecular techniques are far more sweeping. For example, one key approach, known as environmental DNA (eDNA) analysis, allows you to identify all the species in a particular place from their distinct genetic sequences. It often relies on DNA that is secreted into the surroundings, such as water, so you don't actually need to collect the organisms themselves. In the past 20 years, almost 2000 more species of marine fungi have been discovered using various DNA methods. "The application of molecular tools has been a revolution," says Cunliffe.

Life on the ocean waves

Such DNA sampling has revealed that all of the seven major groups of fungi are present in the sea, everywhere and in large quantities. "They exist in every marine habitat where researchers have bothered to look: from hydrothermal vents, subsurface deep-sea sediments and Arctic ice, to surface waters, salt marshes and sandy beaches at low tide," wrote Amy Gladfelter at the University of North Carolina at Chapel Hill in 2019. Subsequent research has also shown that they are abundant in the open ocean, from the top to the bottom of the water column. Almost all marine fungi we know of are microscopic. The most recent estimate of their abundance concluded that of the 6 billion tonnes of carbon in marine biomass, about 5 per cent is fungal. Most of the rest is in multicellular animals, which means that fungi are a major component of oceanic plankton. So what is this biological dark matter up to?

One possibility is that most of it is mere detritus. After all, terrestrial fungi produce vast numbers of spores, which disperse into the air and fresh water, and some will inevitably end up in the ocean. The species discovered by the Kohlmeyers and their predecessors were obligate marine fungi. But that isn't necessarily the case for those discovered by molecular techniques. "Most of the marine fungi – certainly out in open water – are closely related to species that we find in non-marine ecosystems," says Cunliffe. And it wasn't clear whether they are alive because eDNA analysis doesn't distinguish between dead or dormant organisms and living ones.

So, to resolve the issue, Cunliffe and his team used a more refined technique called mRNA analysis. RNA is the intermediate between DNA and proteins, so if fungal RNA is found, it must come from organisms that are metabolically active, and hence alive. The research provides good evidence of this. That would make these incomers at least "facultative" marine fungi, meaning they can survive – and possibly reproduce – in seawater, but only as a plan B.

Even so, this shows incredible resilience and adaptability because living in seawater presents two severe challenges: salinity and pressure. Fungi appear to be up to the task in part because they have extremely thick and durable cell walls, which protect them from harsh external environments. They are also able to adjust these cell walls in response to almost any challenge. Cunliffe and his team have experimented on marine fungi and found that they can deal with radical alterations in pressure and salinity, responding within minutes by changing the shape and composition of their cell walls. Fungi are also metabolically flexible and able to extract energy from almost anything. Again, they quickly change, shifting metabolic gear to deal with unexpectedly finding themselves in seawater. "It appears that fungi that live in surface environments on land can easily adapt to marine environments," says Frank Kempken at the University of Kiel, Germany.

The transition from terrestrial to marine living, called "crossing the salt barrier", is very challenging, biologically speaking. Of all complex organisms, fungi are the most adept at making this leap. A recent analysis found that living things have made the crossing at least 350 times over the course of evolution. But fungi are the champions, making at least 39 and as many as 47 crossings in their evolutionary history. Indeed, they originally evolved and diversified in the ocean, starting around a billion years ago, according to molecular clock estimates, and colonised the land and fresh water around 600 million years ago. There they diversified again, giving rise to around 3 million species. But the switch back to

ROBERT COFFAN

"Molecular analysis opened a new porthole on discovery"

The maritime sunburst lichen is a member of the fungi kingdom that is adapted to a saltwater environment

ES3N/SHUTTERSTOCK

A mushroom found in a stream in Oregon (left) hints that they may exist in the oceans

Early marine fungi researchers, the Kohlmeyers, collected 25,000 specimens (right), which are now held at the New York Botanical Garden

"There is one more discovery that would really be magic: marine mushrooms"

THE NEW YORK BOTANICAL GARDEN

ocean dwelling is only ever a gust of wind away.

Exactly what today's marine fungi are living on is a bit of a mystery. Fungi secrete enzymes to digest macromolecules outside their cells and then transport the smaller products inside. That makes sense if you live in soil or leaf litter, but it is more difficult to pull off in water. This was one reason why their presence in the open ocean had long seemed implausible, according to Kempken. But recent research suggests that they have overcome this problem by glomming onto "marine snow", small particles of organic matter sinking slowly from the surface to the depths. Another discovery, yet to be published, is that many species of seaweed rely on symbiotic fungi, forming a kind of "reverse lichen" where the alga is dominant but the fungus supplies vital services. It would appear that many, or most, marine fungi are symbionts or parasites.

But what are they up to?

Whether they are all reproducing, however, isn't clear. But even if they aren't, itinerant fungi seem to play an important role in marine ecosystems. On land, their feeding habits make them the main recyclers of organic matter, extracting compounds from dead plants and animals and injecting them back into the system. Ditto in the sea… maybe. "We've provided evidence that they're potentially involved in globally important processes, like the biological carbon pump, where organic carbon from surface waters moves to the deep ocean," says Cunliffe. In other words, they help to reduce the amount of carbon in the atmosphere and so limit global warming.

There is probably more. According to Eva Breyer at the University of Vienna, Austria, marine fungi seem to have a role in multiple biogeochemical cycles, including those involving carbohydrates, amino acids and lipids. The significance of this in terms of global nutrient cycling is still an open question. It is one of the many mysteries that still surround marine fungi.

There is another big question occupying mycologists: can they be useful to us? Terrestrial fungi have historically been a prolific source of antimicrobial compounds – think Alexander Fleming and penicillin – and marine fungi could deliver the next generation. "They secrete all these different types of metabolites to try and knock down competitors," says Cunliffe. "We've done some preliminary work screening them against bacteria that might cause infection to people, and some of them seem to be pretty good."

Marine fungi could also be an answer to another scourge of our modern world: pollution. Fungal blooms occur where there has been an oil spill and, by breaking down the hydrocarbons, they accelerate the clean-up. Fungi have also been found living in the vast ocean collection of plastic refuse known as the Great Pacific Garbage Patch and, given their metabolic flexibility, it is thought that they can digest this material. If so, marine fungi could prove an invaluable ally when it comes to getting rid of floating waste.

The more we learn about marine fungi, the more fantastical they seem. But there is one more discovery that would really be magic: marine mushrooms. Sadly, none has been found to date, and their absence makes sense if you think about what a mushroom is, says Cunliffe. "It's the spore dispersal mechanism. Spores disperse in air, so there's no reason why there would be marine mushrooms."

But never say never. In 2010, mycologists unexpectedly discovered a freshwater mushroom, *Psathyrella aquatica*, in a stream in Oregon. The claim remains controversial. But it isn't impossible that something similar exists in the oceans too. "The marine environment is so poorly sampled," says Cunliffe. "It's fractions of a percentage that we've covered." The idea of ocean mushrooms may seem fanciful, but perhaps we just haven't looked deep enough. ▮

Graham Lawton is a features writer at *New Scientist*

KLAWE RZECZY; HEADHOT: MATTHEW PAUL D'AGOSTINO

‘Our thoughts can have a role in our experience of pain’

How exactly the placebo effect works is still a mystery, but neuroscientist **Luana Colloca** is trying to find the answers. She tells David Robson how what we know so far is transforming the way we treat pain

FOR a phenomenon that has been known about for hundreds of years, there is still much to learn about the placebo effect – when a person’s health improves after taking a dummy treatment like a sugar pill. It is thought that the expectation of a positive outcome is behind it, and that a negative expectation is involved in its unwelcome opposite, the nocebo effect, which is when symptoms worsen. But questions remain about exactly how the mind affects the body in this way and why some people experience the effect more strongly than others.

Luana Colloca is among those tackling such questions. A neuroscientist and the director of the Placebo Beyond Opinions Center at the University of Maryland School of Nursing in Baltimore, Colloca and her colleagues have shown how specific gene variants can shape the extent of someone’s placebo response. They are now looking into how best to harness such effects to help soothe pain, which could decrease the use of prescription opioid drugs and the risk of addiction to them. They are also exploring the use of virtual reality, with results published last year showing that it can successfully reduce perceived pain and anxiety levels.

Colloca has rounded up all the latest findings on the placebo and nocebo effects in a book that she has co-edited called *Placebo Effects Through the Lens of Translational Research*. She spoke to *New Scientist* about her work on pain relief, whether the placebo effect can help in treating mental health conditions and how it impacts the way we use wearable tech.

David Robson: Some people might imagine that placebo responses are fake or imaginary. What first persuaded you that they are real?
Luana Colloca: The placebo phenomenon is probably one of the oldest phenomena in the history of medicine, but also one of the most controversial. When I started researching this topic, I had a very sceptical approach. I had just achieved my medical licence and I was assigned as a PhD student to study placebo effects in Parkinson’s disease at the University of Turin in Italy. These patients had severe symptoms – tremors, rigidity and slow movement known as bradykinesia – and they were all candidates for deep brain stimulation, which consists of electrodes implanted in the subthalamic region, a bean-sized area that controls our movement and coordination. When we implanted the electrodes, we could record neuronal activities very precisely.

The patients had been receiving a drug by injection that increases brain dopamine levels and improves Parkinson’s symptoms. While undergoing the surgery, however, they were given an injection of a placebo, which they ›

believed was the real drug – and they saw the same improvements in their symptoms. Despite this having no active ingredient, their rigidity somehow unlocked or the tremor decreased, and they reported feeling better. Through the electrodes, you could see a change in the neuronal activity along with the motor changes. That was my epiphany.

Can the placebo effect be seen with any treatment?
Virtually any treatment can have a placebo component. In some cases, it is the positive mindset that improves the symptoms: the conscious belief that the saline solution or sugar pill is an active drug that will help. But it can also be the result of learning from a previous experience with a drug, through a process called conditioning.

One team, for example, looked at whether you could use a placebo to reduce the amount of immune suppressant drugs needed after a transplant. They asked patients who were taking an immune suppressant twice a day following a kidney transplant to take a placebo that looks identical at two additional times in the day. Without any active ingredient, the placebo dose showed the same suppressed immune response. When a placebo effect is learned, you don't need any conscious expectation of relief; in fact, a patient could be very negative but still experience some benefits.

What causes the effect?
Placebo responses depend on a sort of inner pharmacy – that is, the release of "endogenous" compounds by the body that resemble the active drugs we use to manage symptoms. Placebo pain relief, for example, comes from the release of endogenous opioids, cannabinoids and dopamine.

We have genes that determine the way these endogenous chemicals are processed. The *OPRM1* gene, for instance, encodes for the mu opioid receptor, while the *FAAH* and *COMT* genes encode for enzymes that break down cannabinoids and dopamine. Someone carrying one variant of one of these genes can display higher placebo effects compared with those carrying another. In our lab, we have shown that single nucleotide polymorphisms – variants at a single base position in our DNA – on these three genes can predict the magnitude of the placebo effect.

Of course, these genetic variants alone can't explain everything: we need to study how the environment and genes interact. Along these lines, we're also pursuing research into early life and adversity. One of our ongoing projects suggests that people who have experienced trauma in early life show a smaller placebo effect, and so we are interested to see the way that someone's life history might interact with their genetic variants to determine their placebo responses.

A lot of your work on placebos has centred on pain. Addiction to opioid painkillers is still a huge health crisis. Could a better understanding of the placebo effect help us to reduce dependence on such drugs?
My colleagues and I hope so, along with a general shift in the perception of pain management. We now know that there is a strong "descending pain modulatory system", a kind of top-down processing which means that our thoughts can have a role in our experience of pain. For example, research shows that catastrophising thoughts – such as "there's nothing I can do to reduce the intensity of my pain" and "it's never going to get any better" – can amplify distress and reduce placebo effects. Cognitive behavioural therapy can help people to reframe their experiences and reduce catastrophising, which, in turn, reduces the intensity of the pain that they are experiencing. Someone may not be able to eliminate their pain entirely, but they can aim to reduce it to do the activities that are so meaningful for them.

The idea now is to create personalised pain management. We could identify the people who can manage their pain with non-pharmaceutical approaches and so limit the use of prescribed opioids to those who don't respond to the other pain therapeutics. The best treatment for you may be very different to the best treatment for me.

Have you tried this approach?
In one study, we worked with multi-trauma patients – people who have any kind of injury that you can imagine. We went to the bedsides and told them that "opioids are important in this condition, but we don't expect you to be on opioids for the rest of your life". We gave them this 20-minute education about the full spectrum of pain treatments and they started needing less opioids to treat their pain while they were still in the hospital. We need a multidimensional approach – there isn't a single pill that will treat all pain.

Surprising facts about the placebo effect

SCEPTICISM MAY REDUCE THE BENEFITS OF PSYCHOLOGICAL THERAPY
Almost all medical treatments have the potential to trigger some form of the placebo effect – meaning that sceptical beliefs could impair outcomes. This may be especially important for psychological therapies. The more someone expects to benefit from a treatment like cognitive behavioural therapy for conditions like depression, the more likely it is to improve their symptoms.

THE BENEFITS OF EXERCISE MAY DEPEND ON A PLACEBO RESPONSE
Physical activity can be beneficial for so many different conditions – from diabetes to heart disease and chronic pain – that some doctors describe exercise as a form of medicine. And this, too, includes a placebo component. According to a 2022 review of published studies, our expectations of the benefits of exercise can influence how it alters mood, self-esteem, cardiovascular fitness and blood pressure.

PETS CAN EXPERIENCE A FORM OF THE EFFECT
In the early 2000s, scientists conducting clinical trials for dog epilepsy discovered a curious phenomenon: the animals given a new drug had fewer seizures, but so, mysteriously, did those given placebo pills. We don't know why this was, but one possibility is that the use of pills changes an owner's behaviour, which benefits the dog. If so, it is a kind of placebo by proxy.

Animals can also benefit from conditioning, in which the brain and body start reacting in a certain way to a real drug – and then continue to respond if it is swapped for a placebo pill. **DR**

SHUTTERSTOCK/DAVID PEREIRAS

Some of your research looks at using virtual reality to improve people's pain and anxiety about their symptoms. How does that work?
Virtual reality can be therapeutic. By ourselves, we can't detach from the pain and anxiety we are experiencing. Through virtual reality, however, you can turn someone's attention away from the symptoms they are experiencing with strong visual stimulation and three-dimensional sounds. You can even add smell sensations along with the goggles. Together, this multisensory stimulation helps modulate the brain's perception of pain and other symptoms. It's cost-effective, accessible to most patients and free of the side effects associated with medication, so it has great potential as a tool for chronic pain.

When we offered immersive VR at the hospital bedside, we saw reductions in perceived pain and anxiety, along with changes in objective measures of the nervous system that signal distress. It's unbelievable the engagement we've seen through our research at Maryland: no matter the age, sex or ethnicity, the participants wanted to try it.

Can placebo effects influence treatments for mental health conditions?
There is considerable debate about the potential differences in efficacy of placebo versus mental health therapeutics. There's a very robust literature on the large placebo effects in the treatment of depression with antidepressant drugs, but there is a huge gap in our knowledge for other conditions, such as bipolar disorder and schizophrenia. We do know that there's a relatively small placebo response in obsessive-compulsive disorder, so the effects of our expectations are not universal across all mental health conditions.

> "Virtually any treatment can have a placebo component"

Several factors contribute to placebo responses in mental health conditions, such as expectations and interactions with the physician. Specifically, expectations related to treatment efficacy and side effects could be manipulated to optimise clinical outcomes and reduce side effects. There is growing evidence that expectations during treatment can affect responses to pharmacological and non-pharmacological treatments, including cognitive training, responses to psychedelics and psychotherapy.

Using virtual reality can help reduce levels of pain and anxiety

Wearable tech now gives us a huge amount of information about our health. Does the way we interpret this affect whether it helps us or not?
In general, it's positive to pay attention to our bodies, but for people who tend to catastrophise, it could become detrimental. There have been cases of people running to hospital because they notice their heart rate is high or they see a different spike in their neural recordings, or they might become neurotic about their sleep if they don't get the perfect number of hours.

It's not just wearable technology: patients can now have access to their clinical notes online, information that wouldn't have been available before. Doctors need to be mindful of the potential for this information to create nocebo effects that harm patients.

How has your understanding of the placebo response influenced your own life and how you deal with your own health issues?
My research on placebo, and perhaps more importantly on nocebo, has influenced my perspective on medicine. Understanding the power of beliefs and expectations has made me more attuned to the role of verbal and non-verbal language in patient-doctor communication. Personally, I've become more mindful of the potential impact of these framing effects on my own interactions with patients and study participants, fostering a more careful approach.

The knowledge I've gained about placebo and nocebo effects has shaped how I approach my own health. I consciously incorporate positive thinking and conditioning into my own lifestyle, recognising the potential benefits they may have on overall well-being and healthy habits. When I feel pain, for example, I use a non-steroidal anti-inflammatory pill with a positive mindset, and I feel better with low dosages. It's not about substituting these practices for full-dose treatment, but rather complementing them with positive thinking and other placebo-based strategies. ▮

David Robson is a science writer and author of *The Expectation Effect: How your mindset can transform your life*. He is based in London

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Stargazing at home

Picking out Perseus

February is a good time to spot two stunning constellations, both of which are named from Greek mythology, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

What you need

A pair of binoculars or a small telescope

Stargazing at home appears every four weeks. Share your stargazing successes with us on X and Instagram @newscientist, using the hashtag #NewScientistStargazing

Next week

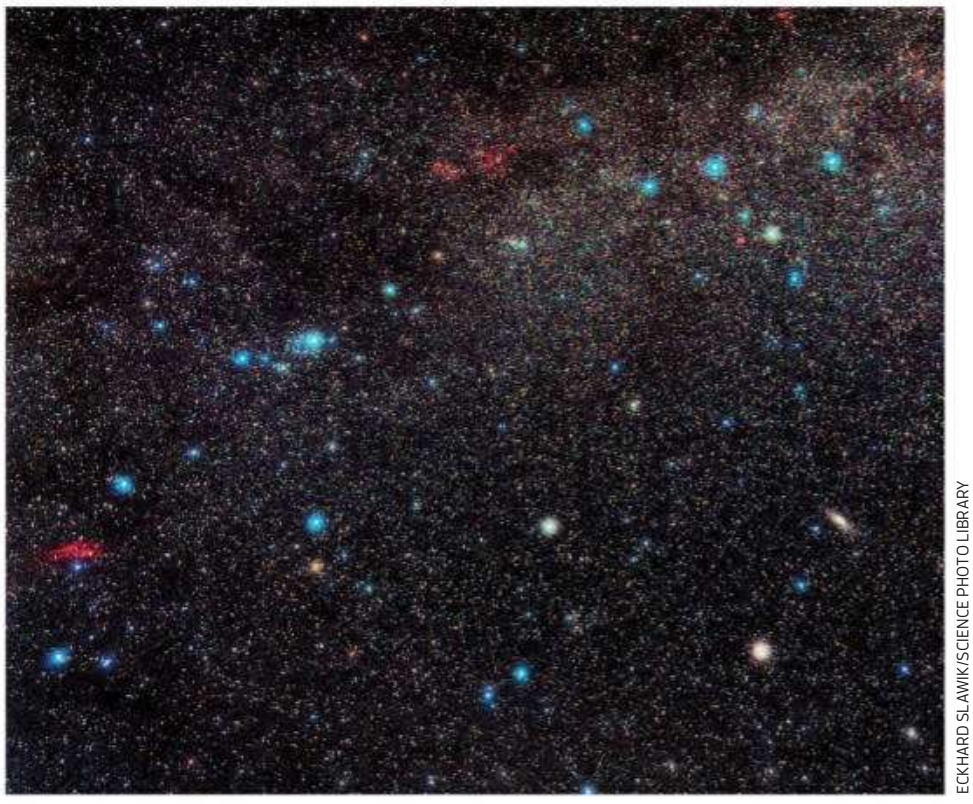
Mathematics of life

THIS week we will be looking for two important constellations that are prominent in the skies around the world during February. They were both named after figures in Greek mythology: Perseus the hero and Auriga the charioteer. They will be visible for most of the evening in the northern hemisphere, but only for an hour or two after sunset in the southern hemisphere, where you should look in a northerly direction.

Perseus (pictured) is one of the biggest constellations in the night sky. Its namesake was said to have saved Andromeda from being sacrificed to the sea monster Cetus, both of which lend their names to other constellations. I like to use this story to remember that Perseus is next to the constellation Andromeda. Perseus is great to spot because it is home to two star clusters, known as the double cluster.

To find Perseus, we can use the neighbouring constellation of Cassiopeia (mother of Andromeda in mythology, and also pictured). It has five bright stars that make a W in the northern hemisphere, or M in the southern. The shallower of these two Vs will be our guide. Take the middle star of Cassiopeia and follow an imaginary line to the star that makes the bottom (or top) of the shallower V. Keep this line going and you will reach Perseus.

You will know you have found it because you will see four bright stars in a slightly curved line. This is the main body of Perseus, and the rest of the constellation forms another line that splits off from this one. Perseus sits between Cassiopeia and Taurus, so if you get to a collection of stars that looks like a tiny version of the Plough, or Big Dipper, you have gone too far – this is the Pleiades star cluster, part of Taurus.



ECKHARD SLAWIK/SCIENCE PHOTO LIBRARY

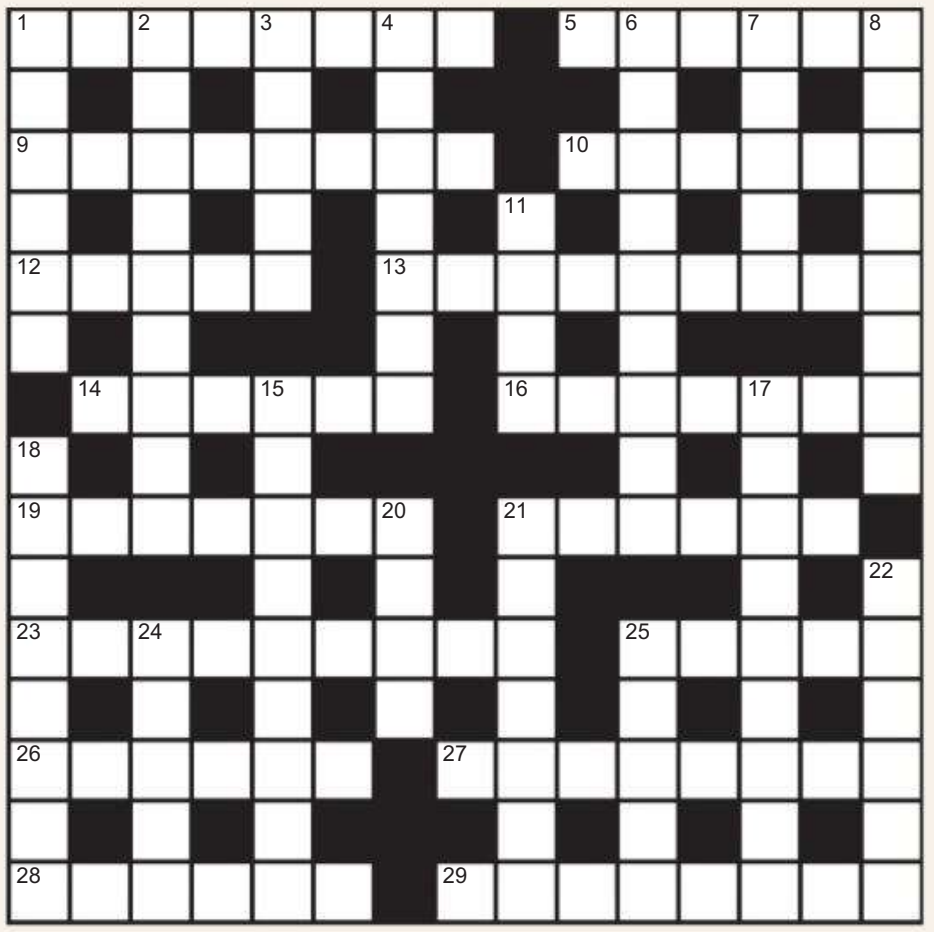
The double cluster is in between Cassiopeia and the brighter stars of Perseus, and both clusters will look fuzzy to the naked eye. But with a pair of binoculars or small telescope you will be able to see hundreds of stars in them. Perseus is also home to a variable triple star system called Algol, which dims for about 10 hours every two to three days, as one of its members eclipses its main one.

Now for Auriga. Once you have found Perseus, follow the curve line of those four stars and you will get to a bright star. This is the sixth brightest in the night sky, and the brightest in Auriga, called Capella (named for one of Auriga's goats). The outline of Auriga is made up of six stars that form a stretched hexagonal shape. The constellation sits between Perseus and Gemini, so if you can spot the twin stars of Castor and Pollux on the other side of Capella, you are looking in the right place.

Auriga also shares a star with Taurus, called Elnath. This sits almost exactly in the opposite direction to the centre of the Milky Way, so when you look at it, you are gazing out of our galaxy into the vastness of the universe. ▮

These articles are posted each week at newscientist.com/maker

Quick crossword #151 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 ___ scale, measure of wind force (8)
5 Mass-specific phenomenon associated with acceleration (1-5)
9 Restore power to (a battery) (8)
10 Fluoxetine brand name (6)
12 Waste water (5)
13 *The* ___, 1912 science fiction novel (4,5)
14 Disease caused by the bacterium *Coxiella burnetii* (1,5)
16 Doctor who performs operations (7)
19 4^2 (7)
21 Migratory finch (6)
23 Growth (9)
25 Former North Sea oilfield (5)
26 Doughnut-shaped (6)
27 Exit slip roads (3-5)
28 Of sound reproduction, multi-directional (6)
29 Mesmerism (8)

DOWN

1 Ba (6)
2 Tundra predator (6,3)
3 Visible fire (5)
4 Frequent; uniform (7)
6 Pyrotechnics (9)
7 Sharp blade (may be Occam's) (5)
8 Encrypting (8)
11 Theories or philosophies (informally) (4)
15 V-shaped car component (3,6)
17 Skin (9)
18 Fibrous mineral, harmful to humans (8)
20 Sturdy, pin-like fastener (4)
21 Biting Dipteran of desert and seashore habitats (7)
22 Stability; stillness (6)
24 Flush out (5)
25 B (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #238
set by Bethan Ackerley

1 Which of the following UK villages is the namesake of a geological age: Kimmeridge, Tolpuddle or Studland?

2 The Vera C. Rubin Observatory was previously known by what name?

3 Which mathematician devised the cellular automaton known as the Game of Life, a type of computational model?

4 The use of penetrating waves, such as X-rays or ultrasound, to create a 3D view of the inside of the body from 2D "slices" is known as what?

5 What did the DONUT experiment detect in the late 1990s?

Answers on page 47

BrainTwister
set by Daniel Griller

#6 Factor factory

The factors of 12 are 1, 2, 3, 4, 6 and 12. It has four even factors and two odd factors, so two-thirds of its factors are even.

What fraction of the factors of 8 are even?

How many whole numbers between 1 and 100 have the property that exactly half of their factors are even?

How many whole numbers between 1 and 1 million have the property that exactly one-third of their factors are divisible by 3?

Solution next week

Easy rider

A cyclist saves energy by staying in the slipstream of the rider in front. But does the rider in front expend more energy than a solo rider travelling at the same speed?

Paul Haydon
Watchfield, Oxfordshire, UK
I am 69 years old. As a teenager, I was a keen cycle racer. When I was 18, I rode 17 road races, with 14 top six finishes (and two visits to hospital!). Later in life, I was a keen tandem cyclist with my wife. I also studied fluid mechanics and aerodynamics at university.

If you look at one cyclist going hard into a headwind, there is a high-pressure area in front of them, which pushes them back, and low pressure behind them, which pulls them back. If a second cyclist joins in behind our leader, the low-pressure area is partially filled, hence the leader has less wind resistance as a pair.

This is most noticeable when riding a tandem. We used to ride orienteering events on our tandem. On the road sections, into a headwind, we would scorch past solo riders.

"We used to ride orienteering events on our tandem and would scorch past solo riders when riding into a headwind"

In the Tour de France, when there is a solo time trial, the riders are followed by a team car with spare wheels and bikes on top. The cars must stay at least 50 metres behind the rider, so as not to assist.

David Muir
Edinburgh, UK
When a cyclist moves, turbulence is produced in the form of vortices, eddies of air behind them. This causes low-pressure areas, creating drag, a force that slows cyclists and against which they must pedal harder to maintain speed. If a second cyclist moves into the space directly behind the first, the low-pressure area will pull the second cyclist along because the air in the vortices rotates from the outside in, and this movement pushes the second cyclist.

Cyclists call this drafting and, counterintuitively, it benefits the first cyclist as well as the second. By occupying the space behind the first cyclist, the second cyclist cuts the first's drag. The first cyclist still needs to work harder than the second, but not as hard as if they were cycling on their own.

Cyclists in a race form a pack called a peloton, where everyone except the lead cyclist benefits from riding in someone else's slipstream. A cyclist in the peloton can use up to around 50 per cent less energy than a cyclist alone.

Things get more interesting if there is a crosswind. Rather than ride in a peloton, cyclists will ride in an echelon, a diagonal line of cyclists, where the lead rider fights the wind, let's say coming from the front and to the right. The second rider will cycle behind and to the left, in the lee of the lead cyclist. When it is time to change the lead cyclist, the front rider peels off to the right and moves back round the echelon to attach to the rear.

David Fishel
Indianapolis, Indiana, US
As a former competitive cyclist, as my several healed fractures attest, I was intrigued by this question.

According to "Aerodynamic drag in cycling pelotons: New insights by CFD simulations and wind tunnel testing", published in the *Journal of Wind Engineering and Industrial Aerodynamics* in 2018, the answer is the lead rider actually benefits as compared with if they were riding solo.

The reason: the following riders, by keeping close to the leader's rear wheel, reduce the rearward sucking effect produced by a low-pressure area that naturally follows the leader. According to the paper, this can generate a 4 per cent or more advantage. Also, the configuration of the peloton can make a difference too, e.g. a single line or a diamond-shaped arrangement consisting of many riders, spread out across the road.

SHUTTERSTOCK/ PEOPLEIMAGES.COM - YURI A

Why does a tickle make us laugh, when it's just a physical sensation on our skin?

This week's new questions

Having a laugh **Why does being tickled make us laugh, when it is just a feeling on our skin?** ***Wyn Hamilton-Wright (7 years old)****, Bristol, UK*

Best thing since **What is the best way, and best knife to use, to minimise crumbs when slicing bread, particularly wholemeal?** ***Peter Slessenger****, Reading, Berkshire, UK*

Middle-earth

Why does our planet have an iron core, rather than one made of another abundant element such as silicon?

Alex McDowell
London, UK
Iron is more dense and hence, when the young Earth was molten, it tended to sink. Lighter elements, such as silicon and aluminium, floated to the surface and, as Earth cooled, the crust contained mainly the lighter elements.

Ken Appleby
Ledbury, Herefordshire, UK
Iron is the densest abundant element and gravitationally settles at the core, displacing all less dense materials. It is the densest abundant element because it is the final product of stellar nuclear fusion.

Squeezing out

What is the shortest space a parked car can get out of? Or a parking car can get into? (continued)

Hubert van Hecke
Santa Fe, New Mexico, US
It is possible to squeeze out of a tight parking spot even if the

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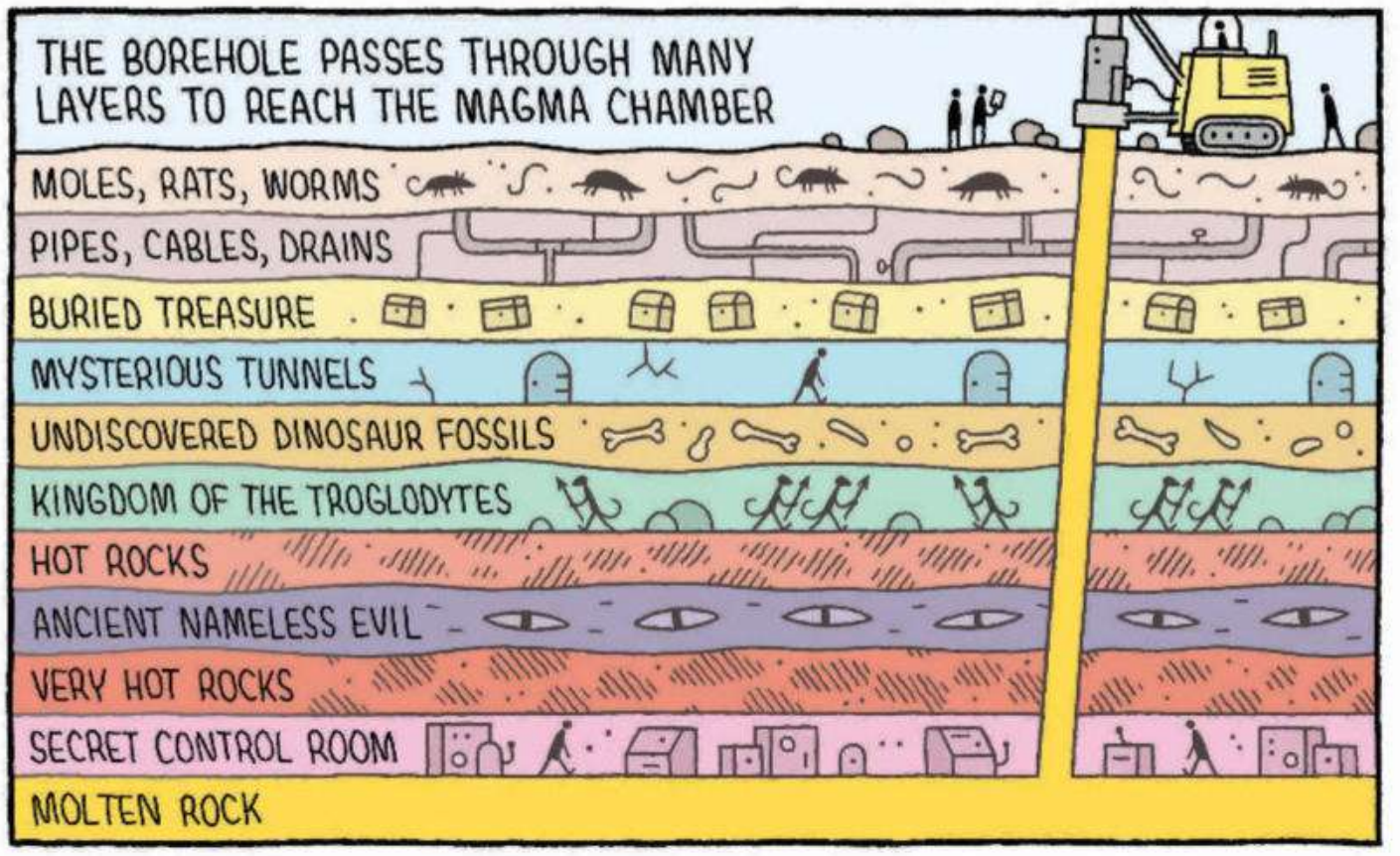
Tom Gauld
for New Scientist



length of the space is less than the diagonal of the car.

Here is how: imagine the curb is to the right and there are cars front and back. Back up to touch the bumper of the car behind. Then cut the wheels to the left and inch forward partly into the gap in front.

About halfway in, cut the wheels to the right and ease forward until touching the car in front. If done properly, you will now be parallel to the curb, but a small distance away from it. Back up straight and repeat.

But what if the gap is zero? This happened to a friend of mine who went on vacation in Sicily, Italy, where he rented a car.

When he found the car, it was parked with bumpers touching the cars to the back and front. So he went back to the service desk to explain his predicament.

The service agent went to the car, got in, started the engine and pushed the car in front until there was enough space, then got out and handed the keys to my friend. Ecco!

"On 22 August 2007, I parked my Audi RS 6 in a space in the Lake District that was at most 6 cm longer than my car"

Bob Cory
Altrincham, Cheshire, UK

Grant Hutchison claims that the record for parking in a tight space is a space 7.5 centimetres longer than the car. I can beat that, and in a car much longer than a Fiat 500.

On 22 August 2007, I parked my Audi RS 6 in a space in the Lake District in the UK that was at most 6 centimetres longer than my car (see photos, right).

The whole process was watched by dozens of people on an adjoining grass bank and at the end they gave me a standing ovation – but no flowers.

Here's how I did it. You must reverse in. Then position the back wheels so they align correctly with the side of the road. You need a person to help stop you hitting the cars behind and in front, especially with an audience. You put a hard right lock on the steering and reverse back until you almost hit the car behind. Then hard left lock and edge forward until you almost hit the car in front. Repeat maybe 20 times – each time you are 5 centimetres further in.

BOB CORY

Mike Piff
Via email

It is the length of the car, provided there are no other cars parked nearby. ▮

Answers

Quick quiz #238 *Answers*

1 Kimmeridge
2 The Large Synoptic Survey Telescope
3 John Conway
4 Tomography
5 The tau neutrino

Cryptic crossword #128 *Answers*

ACROSS 1 Vent, **3** Implants, **9** Hatch, **10** Swelter, **11** At issue, **12** Idled, **14** Sesame, **16** Beacon, **19** Titan, **21** Collate, **23** Orifice, **24** Germs, **25** Lodestar, **26** Edit

DOWN 1 VR headset, **2** Nutrias, **4** Mesmer, **5** Lee tide, **6** Natal, **7** Sir, **8** Thus, **13** Dinner set, **15** Menhirs, **17** Charred, **18** Schema, **20** Triad, **22** Lego, **23** Owl

#5 Diagonal lines *Solution*

Generally, for a shape with n vertices, there will be n(n-3)/2 diagonals. This is because each vertex can join to n-3 others (not including those adjacent to it and itself) and there are n vertices to connect. To avoid counting each line twice, we divide by 2. Hence, a pentagon has five diagonals, a hexagon nine, while a nonagon (nine-sided shape) is the polygon that has three times as many diagonals as vertices.

Learning from mole rats

Feedback anticipates a bonanza of pharma-medico-lifestylish new-product announcements offering to boost everyone's level of hyaluronan, a substance recently shown to somewhat protect your cells against inflammation and early death if you are a naked mole rat.

Marketers who specialise in inflammation of the populace won't have missed the *Journal of Experimental Biology*'s appreciation of hyaluronan. Beneath the headline "Underground anti-aging secrets from burrowing rodents", the journal says: "Most cells live in a blanket of molecules and minerals called an 'extracellular matrix'. In naked mole rats, this blanket is woven from a thicker fabric: naked mole rats produce a heavier and larger version of the molecule hyaluronan, which is the backbone of this extracellular matrix.

"As Andrei Seluanov and Vera Gorbunova's team at the University of Rochester, USA, show, this extra padding protects cells from inflammation and early death."

The report ends with this almost poetical wink: "the Fountain of Youth may be embodied in the heavy hyaluronan of naked mole rats – nearly blind rodents, with lots of wrinkles and yellowed teeth".

Anarchist cookbook tip

Books can be dangerous in little-anticipated ways.

Feedback reminds you to be careful when using *The Anarchist Cookbook*. If you don't cook your anarchist to the proper temperature, there may be problems.

Similarly with *The Shredded Vegan Chef*. If you don't properly shred your vegan chef, distress can result.

If your hobby is astrophysics, the warning applies to *The Whole Earth Cook Book*.

Twisteddoodles *for New Scientist*

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Consideration of items sent in the post will be delayed

Post-deadly encounters

After the world became aware two decades ago of homosexual necrophilia in the mallard duck, more reports of "Davian behaviour" found their way into the public record. Here is a quick update.

The subject got its big boost in 2003 when Dutch ornithologist Kees Moeliker was awarded an Ig Nobel prize for his now-famous paper "The first case of homosexual necrophilia in the mallard *Anas platyrhynchos*". Moeliker told of two ducks that had an avian Davian encounter. Necrophilic behaviour is here called "Davian" because, in 1960, US ornithologist Robert W. Dickman gave necrophilia a new name – "Davian" – in his paper "'Davian behavior complex' in ground squirrels", published in the *Journal of Mammalogy*.

Now, Michal Řeřicha and colleagues at the Czech University of Life Sciences Prague have published a report that documents the practice among ladybirds (known as "ladybugs" in some places). The report's title smacks of horror: "Mating with dead conspecifics in an invasive ladybird is affected by male sexual fasting and time since the female's death".

This comes just three years after a report by Amber Lea D. Kincaid at Mote Marine Laboratory in Florida and colleagues, about necrophilia at sea: "Necrocoitus in common bottlenose dolphins (*Tursiops truncatus*) near Sarasota, Florida".

Attention-grabbing, grim accounts can take a literary turn, as happened in a 2015 paper, about South American snakes, called "The sexual attractiveness of the corpse bride: Unusual mating behaviour of *Helicops carinicaudus* (Serpentes: Dipsadidae)", by Raíssa Siqueira at the University of São Paulo, Brazil, and colleagues. They write: "We observed a young male copulating, with the hemipenis fully inserted into a headless female. Specimens were collected, dissected and measured".

Literary works inspire other literary works, as is evident in a 2020 paper by Marco Colombo and Emiliano Mori at the University of Siena in Italy. The title is: "The 'corpse bride' strikes again: First report of the Davian behaviour in the Eurasian badger".

Happily horrific titles

Some medical papers have titles so intriguingly horrifying that – to anyone who loves a good horror story – the title almost begs the reader to NOT read the study itself.

Why avoid the complete study? Because one's imagination, when overstimulated, can conjure up wonders. In comparison, the actual you-could-go-see-it-yourself details might seem mundane, dull, even comparatively dreary. Reading them could produce literary disappointment and disgruntlement – maybe even the death of curiosity.

For example, consider a paper written by a medical team in Chiba, Japan. To a non-professional, it tells how doctors solve accidental jigsaw puzzles – puzzles each made of odd parts from some person's digestive organs. Chew, please, on the paper's title: "Risk factors of unintentional piecemeal resection in endoscopic mucosal resection for colorectal polyps ≥ 10mm".

Feedback invites you to send easily over-imaginable titles of actual published scientific reports, should you run across any. Please include full citations and links to the papers. Send to: "Happily horrific titles" c/o Feedback. ▮

Marc Abrahams

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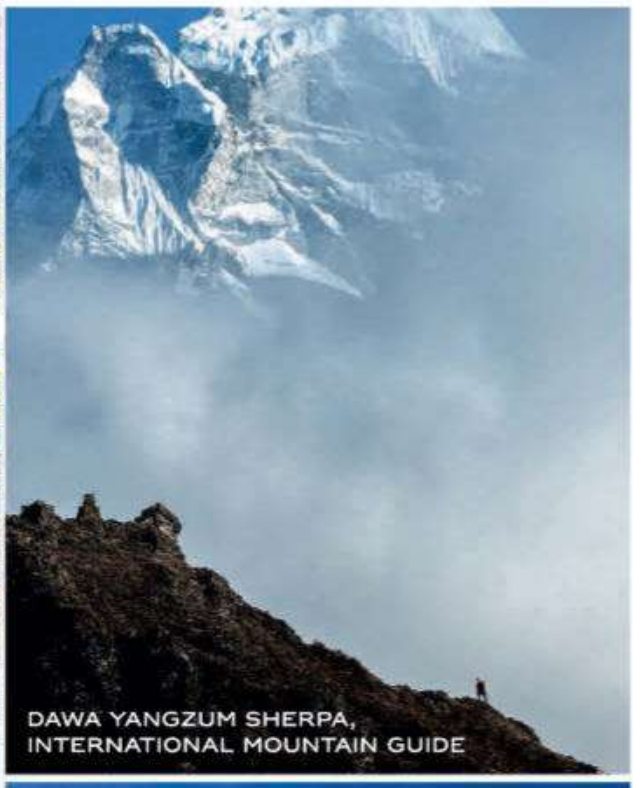

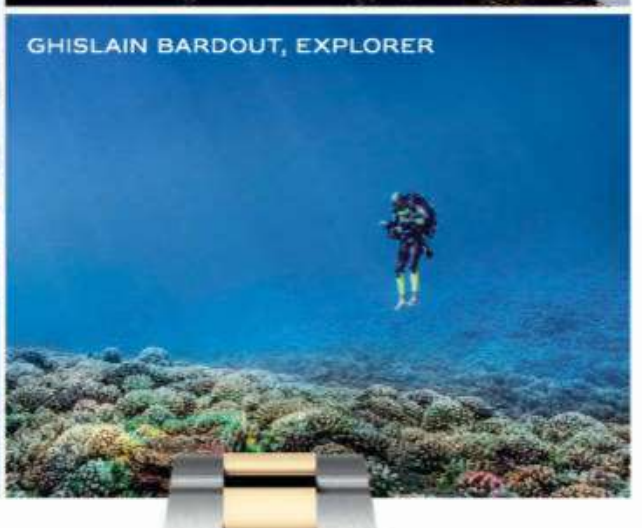

WHAT DO THEY SEEK?

Explorers, adventurers, scientists. Men and women who always broadened the horizons, for all humankind to share. Rolex was at their side when they reached the deepest point in the oceans, the highest summits of the Earth, the deepest jungles and both poles. But now that we know, more than ever, that our world has its limits, why do they continue to venture out there, again and again? Certainly not for kudos, accolades, or an ephemeral record. What they truly seek is to understand more intimately how complex and delicate our planet is, to document its change and how together, we can affect it for the better. So as long as they need it, we will be at their side. Because today, the real discovery is not so much about finding new lands. It's about looking with new eyes at the marvels of our planet, rekindling our sense of wonder, and acting to preserve our pale blue dot in the universe…
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